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JOURNAL OF PALEONTOLOGY, VOL. 7, NO. 4, PP. 359–392, PLS. 40–46, DECEMBER, 1933

THE GASTROPODS OF THE ST. LOUIS, MISSOURI, PENNSYLVANIAN OUTLIER: VI. THE NERITIDAE

J. BROOKES KNIGHT
Occidental College, Los Angeles, California

ABSTRACT

This paper treats of species of *Naticopsis*, *Trachydoma* and *Natiria*, not only as represented in the St. Louis outlier, but as represented in material from other horizons and areas of the American Pennsylvanian. Much of the discussion is based on studies of type specimens.

The genera *Naticopsis* M'Coy, *Trachydoma* Meek and Worthen and *Natiria* de Koninck are discussed and redescribed. Some suggestions are made toward the subdivision of Paleozoic *Naticopsis*, but only a few groupings are attempted. *Naticodon* de Ryckholt and *Neritomopsis* Waagen (genotype *N. minuta* Waagen, here designated) are continued in the synonymy of *Naticopsis*, though they may eventually take status as subgenera. *Platychilus* Gemmellaro (not Cossmann, nor Jakowleff) is placed in the synonymy of *Trachydoma*, but *Trachyspira* Gemmellaro, placed in synonymy by Cossmann, is removed to the Trocho-turbinidae. *Turbonitella* de Koninck is very close indeed to *Trachydoma*. It is suggested that *Natiria* de Koninck be used for the Paleozoic species commonly referred to *Naticella* Muenster (not Grataloup, nor Guilding) and perhaps for the Triassic species as well.

The family relationships and phylogeny of the genera are considered. It is suggested that the relationship between the genera sometimes referred to the Naticopsidae, Neritopsidae and Neritidae is too close to warrant placing them in separate families. They are here placed in the family Neritidae which is subdivided into two sub-families, the conservative Neritopsinae (new subfamily), including genera from Paleozoic to Recent, and the progressive Neritinae (new subfamily), Mesozoic to Recent. It is held that the Neritidae are far removed from the platyceratid genera such as *Diaphorostoma* Fisher to which they are supposed by some authors to be related.

American Pennsylvanian species of *Naticopsis*, *Trachydoma* and *Natiria* are discussed and a number are redescribed. The following new species are erected: *Naticopsis meeki*, *N. wortheni*, *N. virgata*, *N. marthaae*, *N. judithae*, *Trachydoma oweni*, *T. sayrei*, *T. newelli*, *T. moorei*, *T. whitei*.

INTRODUCTION

This, the sixth paper of a series dealing with the remarkably varied and well-preserved gastropod fauna of the St. Louis, Missouri, Pennsylvanian outlier, treats of the genera *Naticopsis*, *Trachydoma*, and *Natiria*, here referred to the Neritidae.

In the previous papers of the series descriptions of species have been limited to forms represented in my collections from the rather short stratigraphic section exposed in the St. Louis outlier. However, various friends have made available to me much supplementary material from the American Pennsylvanian and advantage has been taken of this fact to consider some interesting related forms from other horizons and areas. Some of these neritid species seem to have at least some of the qualities of useful guide fossils, namely distinctive characters and a relatively limited stratigraphic range. These forms have been of very little stratigraphic value in the past since

almost any species of *Trachydoma* passes as *Trachydomia wheeleri* and any *Naticopsis* as *Naticopsis altonensis;* naticopsid steinkerns, of whatever species, are referred commonly to *Naticopsis torta* or *Naticopsis remex.*

Owing to the lack of striking ornamentation in species of *Naticopsis*, difficulties in making precise identifications of the material at hand from the literature were anticipated, and every effort was made to obtain type speciments. The response made by those in charge of various depositories was truly gratifying. While acknowledgment will be made to each at the proper place, it should be stated here that whatever value my efforts to straighten out the tangle may have is due largely to the generous cooperation of these various institutions extended through their curators. All of the borrowed types are refigured here from photographs. In addition, I am especially indebted to Dr. Norman D. Newell, of Yale and the Kansas Geological Survey, for the loan of much new material, and to Mr. John B. Owen, of Clinton, Missouri, for a fine collection from a classic locality in western Missouri.

No pretense is made that this study solves all problems concerning American Pennsylvanian Neritidae. On the contrary, it is fully realized that, in spite of the material so generously put at my disposal, much more extensive collections from many more horizons and localities must be studied before we can even begin to know the characters, the range in time and in space and the interrelationships of the species of this interesting and potentially useful group of gastropods. A bare beginning only is made.

Registers of localities have been furnished with two of previous papers of this series (1a, 1c) and a detailed discussion of the stratigraphy of the St. Louis Pennsylvanian outlier with a full list of localities is to be found in the *American Journal of Science* for the current year (15). The reader who is interested in exact localities from which the specimens from the St. Louis outlier were collected is referred to those papers. Other localities from which specimens were derived are given as fully as possible in the text.

The illustrated specimens (except those that are announced as borrowed or as the property of other institutions) are deposited in the collections of the Peabody Museum of Natural History at Yale University. Unfigured types, in so far as they are available, will be deposited with the United States National Museum in Washington, at Washington University in St. Louis and at the Musée Royale d' Histoire Naturelle in Bruxelles, Belgium.

In order to avoid the introduction of subjective, interpretative matter into the illustrations, since these represent the evidence on which interpretative conclusions are based, the photographs of specimens on the plates have not been retouched.

Acknowledgment is made to the Sterling Fund of Yale University for assistance in the preparation of this paper.

Family NERITIDAE Fleming, 1828
Genus NATICOPSIS M'Coy, 1844

The name *Naticopsis* was proposed by M'Coy in 1844 (2, p. 33) for a group of gastropods which before that time had been commonly referred to *Ampullaria*, *Natica* and *Nerita*. Included among the species described was *N. phillipsii* M'Coy, which was designated genotype by Meek and Worthen in 1866 (3a, p. 364, footnote). *N. ampliata* (Phillips) has been considered the genotype by some European workers, but Meek and Worthen's designation of 1866 is valid and seems to have priority. It must, therefore, stand.

Naticopsis may be described as follows:—Neritiform to naticiform gastropods with relatively low spire, a thick shell, and anomphalous base; volutions rapidly increasing in size, the body whorl forming most of the shell; plane of the aperture markedly oblique; outer lip thin; columellar lip strongly arcuate, thickened and sometimes with an obscure groove within; parietal inductura strongly thickened and sometimes flattened in the plane of the aperture, often bearing transverse rugae; a narrow channel at the juncture of the outer lip with the parietal wall, probably excurrent; often without ornamentation but with a tendency to fine, transverse lirae which in turn show a marked tendency to fasciculation into costae near the sutures; color markings commonly either zigzag transverse stripes, revolving bands or both combined, often preserved. There is no nacreous layer, but the outermost shell layer, probably calcitic in life, is very resistant to alteration; inner whorls not resorbed; nucleus low, simple and dextral. The operculum is calcareous, moderately thick, oval or subcircular, with growth lines concentric on an excentric, but not marginal nucleus; inner surface with subreniform raised area.

It may not be out of place here to attempt a brief description of two characters that I must confess I do not fully understand but which seem to be observable on many specimens of the genus *Naticopsis* from Mississippian to Permian in age that have the requisite preservation. These characters have to do with the structure of the shell itself.

The first of these structural characters seems to be confined to the outermost shell layer and consist of very fine, intermittent lines of different texture, oriented with their length parallel to the whorl. The second seems to be a structure in the deeper layers of the shell, though in some exceptionally well preserved specimens it may be seen as though through a translucent layer. This second structure is expressed as very fine alternations of greater or less translucence parallel with the growth lines. These transverse structures seem, in some instances, to have some effect on the weathering of the shell, as corrosion may etch one set a little faster than the other, thus allowing one set to stand slightly in relief. It is thought that these two characters represent a peculiar development in *Naticopsis* of two sets of crossed-lamellar structures, each in a different layer and each normal to the other.

Columellar sections of *Naticopsis*, *Trachydoma* and *Natiria* have proved most unsatisfactory since the columella is so exceedingly arcuate that only short sections of it can be seen in any given plane. A columellar section seems to show, as a result, wholly or partially resorbed whorls, when in fact the seemingly missing parts are not missing except from any given section. Because of this, sections are not used in this paper as an aid in studying a species as they have been for some of the other natural groups, although a number of sections were prepared.

A feature of especial interest for *Naticopsis* in particular is the remarkable series of ontogenetic changes that occur in a number of species, the form at each growth stage being different, often so different as to make it difficult to recognize two specimens as belonging to the same species without a rather complete suite. These ontogenetic states will be discussed more fully under the species concerned, but certain characters that seem to have a general application to species of the genus should be considered here.

Some authors have considered the presence or absence of transverse rugae on the characteristically thickened inductura as of specific value. It has been my observation, however, that such rugae are developed by some individuals of almost any species and not by others. In all cases observed, the rugae are developed, if at all, at ephebic stages and most commonly at early ephebic stages. I have not observed them at either neanic or gerontic stages.

The gerontic characters in *Naticopsis* deserve especial mention. Most noticeable of these is the almost abrupt change in the course of the line of the suture that has been observed in many of the species described in the following pages. The sutures remain parallel, one with the other, until old age sets in, when the final half whorl seems to bend down (or forward) so that the angle of the suture is markedly increased and it passes obliquely downward across the face of the previous whorl. Thus, in the large specimen of *N. ventricosa*, shown on Plate 41, as figures 2*g–i*, the sutures for all but the last half whorl are at an angle of about 5° to a plane normal to the axis of the shell, but in the last half whorl this angle becomes about 22°. This character of senescence occurs in enough species to suggest that it may be universal in *Naticopsis*, although, owing to the scarcity of gerontic individuals, it may not always be possible to demonstrate it.

The name *Naticodon* was proposed by de Ryckholt in 1847 for species of *Naticopsis* which seemed to him to show a tooth on the columella. The genotype is *N. globosa* (Hoeninghaus). De Koninck has pointed out that this is not morphologically a tooth (4, p. 11) and that *Naticodon* belongs subjectively in the synonymy of *Naticopsis*. I have some specimens from Tournai that show the character used by de Ryckholt and I am quite in accord with de Koninck's conclusion.

Neritomopsis Waagen, 1880, genotype *N. minuta* Waagen (here designated), is a subjective synonym of *Naticopsis*, unless some scheme is devised by which certain strains within the latter genus may be differentiated.

I have given much thought to the matter of subdividing *Naticopsis* and though the idea seems to give some promise, since there are several well marked phyletic lines within the genus, any subdivision into subgenera should await more complete collections from a greater time range than are available to me now. Work based too much on the literatures does not lead to reliable conclusions. Nevertheless, certain groupings of American Pennsylvanian species seem to be natural and will be employed here. It would be unwise at this time, and without a much wider study, to give them designations that might enter into nomenclature. These groups are:—

1. The group of *Naticopsis subovatus* Worthen, characterized by low spire and globose shape at all growth stages. *N. ampliata* (Phillips), from the Mississippian of Europe seems to belong here. The American Pennsylvanian species include:

N. subovatus Worthen
N. wortheni Knight, n. sp.
? N. pulchella Morningstar

2. The group of *Naticopsis virgata* Knight which includes *N. shumardi* (McChesney). In this group the early stages are low-spired and ventricose but at ephebic stages the sides of the whorls are flattened and the shell becomes markedly elongate.

3. The group of *N. ventricosa* Norwood and Pratten which seems to include *N. elliptica* from the Mississippian of the British Isles. In this group the early stages have rather high spires for the genus and evenly rounded, unshouldered whorls without ornamentation. At ephebic stages the whorls take on subsutural shoulders ornamented with transverse lirae while the upper half of the whorl below the suture becomes concave in profile, rather than evenly convex. The American Pennsylvanian species are:

N. ventricosa Norwood and Pratten
N. meeki Knight, n. sp.
N. gigantea Meek and Worthen.

Still other groupings will undoubtedly suggest themselves as further species become known. The groups may eventually appear sufficiently distinct to merit recognition as subgenera, in which case the synonyms *Naticodon* and *Neritomopsis* may warrant revival as subgeneric names for some of them.

Genus TRACHYDOMA Meek and Worthen, 1866

The name *Trachydomia*, here amended to *Trachydoma*[1] was introduced by Meek and Worthen in 1866 (3a, p. 364), genotype by original designation, *Naticopsis nodosa* Meek and Worthen, redescribed herein. The genus may be defined as follows:—

Littoriniform gastropods with thick shell, moderately low spire and anomphalous base; volutions rapidly increasing in size, the body whorl forming most of the shell; sutures well

[1] Meek and Worthen give the derivation of the name as τραχύς (=rough) and δῶμα (=house). The stem of δῶμα is δωματ-, not δωμ-. Hence Meek and Worthen might have correctly written the name as *Trachydomatia* or, maintaining the nominative form, as *Trachydoma*, but not as *Trachydomia*. The emendation to *Trachydoma* seems preferable as involving the least change but it must be borne in mind that the name is neuter in gender. Cossmann emends the name to *Trachydomus* but in so doing he goes beyond the derivation.

marked, but not deep, a somewhat collar-like unornamented area just below the suture; plane of the aperture somewhat oblique; outer lip thin; columellar lip arcuate, thickened and with a well marked groove within; parietal inductura thick, flattened and extended in the plane of the aperture; a channel at the juncture of the outer lip with the parietal wall, probably excurrent; nuclear whorls smooth, simple and dextral; nepionic ornamentation for about one whorl fine transverse lirae parallel to growth lines, the lirae breaking up into rows of nodes or pustules, which are in some species small and fine but in others very coarse; inner whorls not resorbed; operculum unknown although, because of the evident close relationship to *Naticopsis*, an operculum similar to that of *Naticopsis* may be assumed with reasonable safety.

In the ontogeny of any species the nodes or pustules become increasingly large and irregular with age, and great care is sometimes needed to distinguish the mature specimens of a relatively finely and evenly noded species from the young of one that has, at adult stages, much coarser and more irregular nodes.

Platychilus Gemellaro, 1890 (not Cossmann 1888, nor Jakowleff 1874) is a subjective synonym of *Trachydoma*, but *Trachyspira* Gemellaro, 1890, cited as a synonym by Cossmann, is not. The latter, though it resembles *Trachydoma* somewhat in its ornamentation, is properly referable to an entirely different group of family rank, the Trocho-turbinidae.

Turbonitella de Koninck, 1881 (4, p. 72), genotype by subsequent designation (9, vol. 10, p. 27) *Turbo biserialis* Phillips (see Pl. 45, fig. 1*a-d*), is very close to *Trachydoma*, so close indeed that I hesitate to acknowledge it as distinct. Yet, since its ornamentation is only prophetic of *Trachydoma*, it may tentatively be considered a separate, but very closely related genus.

Genus NATIRIA de Koninck, 1881

In 1881 de Koninck proposed the name *Natiria* (4, p. 6) for *Natica lirata* Phillips (see Pl. 46, fig. 6) which is the genotype by monotypy. The genus may be diagnosed as follows:—

Naticiform gastropods with moderately low spire, anomphalous or minutely phaneromphalus base; volutions rapidly increasing in size, the body whorl forming most of the shell; plane of the aperture rather oblique; outer lip thin; columellar lip arcuate, thickened and with a well marked groove within; parietal inductura somewhat thickened and slightly extended in the plane of the aperture; nuclear whorls smooth, simple and dextral, post-nuclear whorls ornamented by thin, widely-spaced, transverse costae, paralleling the growth lines, which in some species (the genotype) are crossed by revolving lirae which may give them a frilled appearance; operculum unknown though presumably similar to that of *Naticopsis*, the earlier whorls may be dark (as in the genotype) but no other color pattern known.

The above diagnosis is based on a consideration of de Koninck and

Phillips' descriptions and figures of the genotype, supplemented by the American species redescribed herein.

Since *Naticella* Muenster, 1841 (not *Naticella* Grataloup, 1840 nor Guilding, 1840) must be suppressed as a homonym and since the Carboniferous, if not the Triassic, species commonly assigned to it seem to be referable to *Natiria*, it will not be necessary to replace the former name, unless a study of the Triassic genotype shows that a new name is needed.

FAMILY RELATIONSHIPS

Zittel places *Naticopsis* and *Natiria* in the Neritopsidae, *Turbonitella* in the Littorinidae, and *Trachydoma* in the Purpurinidae (5, pp. 456, 457, 461); de Koninck (4, pp. 5, 9) *Natiria* in the Naticidae, *Turbonitella* in the Turbinidae, and *Naticopsis* in the Neritopsidae. Koken, who in 1889, seems to have misconceived wholly the relationships of these genera, treats of *Naticopsis* under the caption "Capuliden und Verwandte" (6, p. 470), but in 1897 he places *Naticopsis* in the Naticopsidae (7, p. 100), Perner places *Naticopsis* in the Neritopsidae (8, p. 280). Meek in 1866 (3a, p. 364, 365) discusses the relationship of *Naticopsis* and *Trachydoma* to the Neritidae, and due to the nonresorption of the inner whorls and the concentric nature of the operculum decided to hold them distinct from the Neritidae and proposed the name Naticopsidae for them. Cossmann places *Naticopsis* in the Naticopsidae (9, **13**, p. 69), *Turbonitella* in the Cyclonematidae (9, **10**, p. 27), *Natiria* in the Neritopsidae (9, **13**, p. 87) and *Trachydoma* in the Trochonematidae (9, **11**, p. 327).

Meek's solution of the problem seems the closest to nature although it is difficult to see that the relatively unimportant characters acquired rather late in the history of a seemingly closely knit group should lead to the placement of different genera of such a group in different families.

The recent genera *Nerita* and *Neritopsis* are definitely Aspidobranchia, of the suborder Rhipidoglossa, and there can be no question that our Paleozoic genera are to be classed with them. The very young specimens of naticopsids, some of which will be described in the following pages, remind one very strongly of *Holopea* and it does not seem unreasonable to suppose that *Naticopsis* might have been derived from some *Holopea*-like genus of the Trochoturbinidae, the changes being the loss of the nacreous character of the inner shell layers, and thickening of the shell, particularly about the columellar and parietal borders of the aperture.

Some of the more globular naticopsids have a striking resemblance to certain species of the platyceratid genus *Diaphorostoma*, but this is certainly a case of convergence. Except for the globular shape and rapidly expanding whorls, two characters common enough in many wholly unrelated genera, the naticopsid genera have nothing in common with the platyceratids.

Naticopsis seems to appear first in the Devonian where it is represented, among others, by that striking species *Naticopsis subcostata* (Goldfus), commonly referred to Turbonitella de Koninck. *N. subcostata* has its finer transverse lirae strongly developed, even on the sides of its whorls, and they fasciculate on the shoulders in true naticopsid fashion to form rather strong costae in that position. The color pattern of this species is often preserved and shows three revolving series of broad, dark splotches the lower of which take on the zigzag character so characteristic of the Neritidae from the Paleozoic to Recent. *N. subcostata*, indeed, has so much in common with all four genera that it might be regarded as a "collective type," a concept that is exceedingly popular with some authors.

In the Mississippian, *Naticopsis* gives rise to *Natiria* and *Turbonitella;* in the Pennsylvanian, *Trachydoma* appears, almost certainly out of *Turbonitella*. *Turbonitella* seems to be confined to the Mississippian but *Trachydoma* goes into the Permian and both *Naticopsis* (s.s.) and *Natiria* seem to be represented in the Triassic. Beginning with the Triassic, there occurs a more rapid evolution leading through the several genera and subgenera proposed by European workers dealing with Triassic gastropods, to *Nerita* and *Neritina*, with resorbed inner whorls and a paucispiral operculum on one hand, and to the more conservative *Neritopsis* on the other. Indeed neritids are a striking example of a conservative Paleozoic stock persisting through to the present day with vitality undiminished. There are some factors that seem to argue for the derivation of the post-Paleozoic Neritopsidae out of *Trachydoma* and that view is tentatively adopted here.

This group of genera seems much too compact to be split among two families, though there seems to be valid grounds for subdividing the Neritidae into two new subfamilies, the progressive Neritinae diverging from the more conservative Neritopsinae in the Mesozoic. These concepts are expressed diagramatically in figure 1.

AMERICAN PENNSYLVANIAN SPECIES

Naticopsis.—There are in the literature some thirteen specific names for American Pennsylvanian species that are properly referred to *Naticopsis*, although some of them have appeared under faulty generic references. These species are, for the most part, poorly known and often confused, while a number of them are synonyms, as yet unrecognized as such. There are certain difficulties presented by *Naticopsis* that are, to a degree at least, peculiar to itself and which must be taken into account whenever its species are dealt with.

One of these difficulties is that, due to the thickness of the shell parts in many species, a naticopsid steinkern may look like something wholly unrelated to the species from which it is derived. Gastropod steinkerns should never be used as the basis for

names, but most particularly is this true of naticopsids.

A second difficulty, and perhaps the most serious one, is the remarkable series of ontogenetic changes previously mentioned. Isolated specimens of the same species at different growth stages have a very different appearance and have, in some cases, formed the basis for different specific names. Girty was the first to call attention to the striking changes in shape and sculpture during growth in one species in a very interesting paper published in 1912 (14). Thanks to the capable amateur collector, Mr. John B. Owens, of Clinton, Henry County, Missouri, I have a splendid suite of the same species studied by Girty and from the same horizon and locality. I have also been able to assemble from my own collections, and others available to me, rather complete series for most of the species to be described herein. These ontogenetic changes will be described in detail for the species for which they are known.

In the following brief mention of species in the literature the species marked with an asterisk are those the types of which I have had opportunity to examine.

The following species are described from steinkerns and are therefore useless and unrecognizable:

TENTATIVE PHYLOGENY OF THE NERITIDAE.
with special reference to the Paleozoic genera.

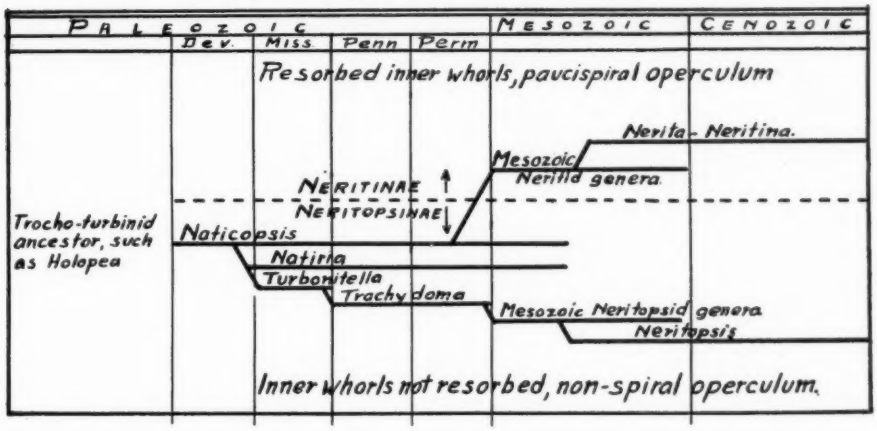


FIG. 1

Naticopsis torta (Meek), *1871*, described as *Platyceras*. (See Pl. 44, fig. 2.)

*Naticopsis peoriensis** (McChesney), *1860*, described as *Platyostoma*. (See Pl. 43, fig. 1.)

*Naticopsis remex** White, *1876*. (See Pl. 44, fig. 4.)

Relative to my conclusion that the first named species, the types of which I have not seen, is founded on a steinkern, a conclusion which runs counter to Meek's direct statement (19, p. 345), compare Plate 44, figure 2, a copy of one of Meek's figures (19, Pl. 20, fig. 1*a*) and Plate

44, figures 1*a–b*, a steinkern of *N. ventricosus*. The conclusion seems unescapable that Meek's types were steinkerns, and that the thin shell he thought he saw on one of the specimens was either the remnant of the innermost shell layer, or a thin layer of mineral matter. It was probably the latter, as such are rather common on steinkerns of any species and may be very deceptive.

Naticopsis nana (Meek and Worthen) 1860, described as *Platyostoma* (best described and figured in 3[a], p. 365, Pl. 31, figs. 4*a–b*), is also insufficiently established to be useful without the study of its type specimen in connection with an ontogenetic series from the type locality. I have been unsuccessful in finding the types though they are, no doubt, in existence. The name is obviously based on a partly grown individual of some species, probably of the group of *N. ventricosa*, but from the author's description and admittedly faulty figure, it is impossible to use the species.

Valid and recognizable species are:—

Naticopsis ventricosa (Norwood and Pratten), *1855*, described as *Natica ventrica*.
Synonyms *Naticopsis pricei* Shumard, *1858*.
Naticopsis altonensis (McChesney), *1865*, described as *Natica*.
*Naticopsis shumardi** (McChesney), *1860*, described as *Natica*
*Naticopsis subovata** Worthen, *1873*.
*Naticopsis scintilla** Girty 1915
Synonyms *Naticopsis gigantea** Meek and Worthen, *1873*, described as a variety of *N. altonensis*, (not *Naticopsis gigantea* Hall and Whitfield, *1872*)
*Naticopsis pustulosa** (Sayre), *1930*, described as *Trachydoma*.
*Naticopsis pulchella** Morningstar, 1922.

Naticopsis monilifera White and *N.* (?) *minuta** Sayre are referable to *Angyomphalus* Cossmann and have been discussed in a previous paper (1e, p. 46).

To the five valid and recognizable species listed above may be added the following described here as new: *Naticopsis meeki*, *N. wortheni*, *N. virgata*, *N. marthaae*, *N. judithae*,

Trachydoma.—Trachydoma wheeleri (Swallow), a species that was never figured by its author is often cited but is, I feel, unrecognizable from the literature. The current concept of the species, which includes the young of almost any member of the genus and adults with relatively small and closely spaced pustules, is derived from Meek and Worthen's figures (3b, Pl. 28, fig. 3*a*, *b*). Meek and Worthen's illustrations carry no authority whatever since they do not represent anything but a subsequent identification from a region far distant from the type localities, and presumably based wholly on Swallow's description. If there is anything in Swallow's original description that would characterize his species as against any other known member of the genus, it is his statement that the pustules on his specimens have slight depressions on their summits. This character has never again been noticed in any other citation of the species and it seems best to relegate the name to the small print of the bibliographies unless and until it can be made useful by description and re-illustration from topotype material. Swallow's types

are known to have been destroyed.

A second species assigned to the genus, *T. pustulosa* Sayre, is discussed under *Naticopsis scintilla*, in the synonymy of which it belongs.

Three species, *T. nodosum* (Meek and Worthen), with the variety *hollidayi*, a synonym of the former, *Trachydoma ortoni* (Whitfield) and *Trachydoma nodulosum* Worthen are valid and recognizable. The types of the first are shown on Plate 45, figs. 2*a–d*, of the second on Plate 46, figure 5, and a topotype of the third on Plate 46, figures 3*a–b*.

In addition to the three recognizable species just mentioned, five new species are described herein, *Trachydoma oweni*, *T. sayrei*, *T. newelli*, *T. moorei* and *T. whitei*, making eight in all, most of which seem assignable to rather definite stratigraphic zones.

Natiria.—The only described species of this genus in the American Pennsylvanian is *N. americana* (Girty) which has been reported only from one horizon and locality, where it is associated with *Naticopsis ventricosa* and *T. oweni*, (12, p. 375, Loc. 1268A2).

DESCRIPTION OF SPECIES

Family NERITIDAE Fleming, 1828.
Sub-family NERITOPSINAE Knight, n. subfam.

Genus NATICOPSIS McCoy, 1844

NATICOPSIS VENTRICOSA
(Norwood and Pratten)

Plate 41, figures 2*a–j*, Plate 42, figures 2*a*, Plate 44, figures 1*a–b*.

Natica ventrica NORWOOD and PRATTEN, *1855*, Jour. Acad. Nat. Sci. Philadelphia (2), **3**, p. 76, pl. 9, fig. 10*a*, *b*. Pennsylvanian, New Harmony Indiana.

Naticopsis (*Nerita*) *pricei* SHUMARD, *1858*, Trans. St. Louis Acad. Sci., **1**, p. 202, Pennsylvanian, Boone County, Missouri. (Type locality Hinkston Creek, Boone Co. Mo.)

Natica altonensis McCHESNEY, *1865*, Desc. New Paleozoic Foss., Illustrations New Species Foss., pl. 2, figs. 14*a*, *b*. Pennsylvanian, Alton, Illinois.

Naticopsis altonensis (McCHESNEY), *1868*, Trans. Chicago Acad. Sci., **1**, p. 50, pl. 2, figs. 14*a–c*, Pennsylvanian, Alton, Illinois; Meek and Worthen, *1873*, Geol. Survey Illinois, **5**, p. 595, pl. 28, fig. 11, Pennsylvanian, Hodges Creek, Macopin County, Illinois; Girty, *1912*, Am. Jour. Sci., (4), **34**, p. 338, pl. 1, figs. 1–8, 100± feet below top of Cherokee shale, Pennsylvanian, near Garland, Henry County, Missouri; Morningstar *1922*, Geol. Survey Ohio, (4), **25**, pp. 255–256, pl. 15, fig. 15.

Naticopsis ventricosus (NORWOOD and PRATTEN), Meek and Worthen, *1873*, Geol. Survey Illinois, **5**, p. 592, pl. 28, fig. 13, Pennsylvanian, New Harmony, Indiana.

Not *Naticopsis altonensis* of White, 1881, nor Morgan, 1924.

Not *Naticopsis pricei* of Sayre, 1930.

Moderately large, neritiform gastropods, which at adult stages have a shallow, but well marked spiral groove passing around the upper half of the whorls, the groove bounded by the swollen or shouldered subsuteral region and a subangular, revolving ventricosity a little below mid-whorl height; shoulders set off from the spire by rather deep sutures and ornamented by rather strong, coarse costae, which die out below the shoulders; parietal inductura thickened, somewhat flattened and extended in the plane of the aperture, in some half-grown specimens, crossed by faint transverse rugae; color pattern rather broad zigzag transverse bands.

The above brief description is drawn from mature specimens such

MEASUREMENTS OF *Naticopsis ventricosa*

	A	B	C	D
Number of whorls	6[a]	5½[b]	5[c]	4½
Height	42 mm.	27 mm.	19 mm.	6.5 mm.
Width	36 mm.	23½ mm.	17½ mm.	5.6 mm.
Ratio of height to width	1.16	1.15	1.08	1.15
Ratio of height of body whorl to total	0.96	0.96	0.96	0.92
Pleural angle	66°[d]	54°[d]	56°[d]	110°[e]

A. A large gerontic individual (Pl. 41, figs. 2*h–j*).
B. A mature, rather narrow and strongly shouldered individual (Pl. 41, fig. 2*c*).
C. A rather wide, mature individual (Pl. 41, figs. 2*e–g*).
D. A late neanic individual (Pl. 41, fig. 2*a*).

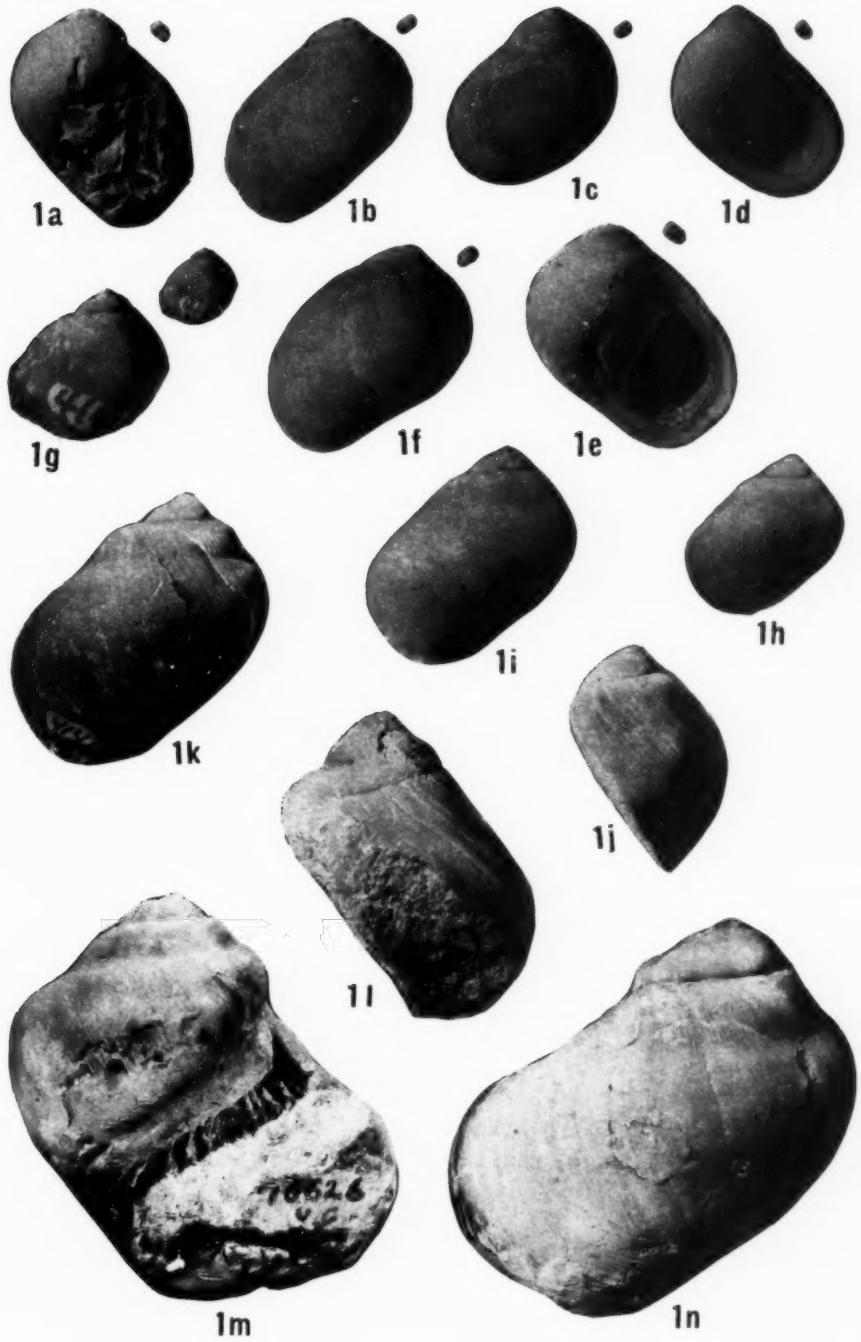
a Based on the assumption that 2 apical whorls are missing.
b Based on the assumption that 3 apical whorls are missing.
c Based on the assumption that 1 apical whorl is missing.
d Measured on final whorl, shoulder to widest part. Owing to shouldering it is impossible to measure this angle in the usual way.
e Measured the usual way.

as shown on Plate 41, figures, 2*b–g* which are of the size most frequently seen in the field, but gerontic individuals and especially the very young differ from such mature forms very markedly. The nucleus, which includes the nepionic shell, consists of about two, smooth rounded whorls with moderately deep sutures. The neanic shell, which stage carries through the fourth whorl, shows a smoothly rounded whorl profile with neither shoulders, ventricose band, groove or ornamentation other than fine lines of growth. In the neanic shell, the parietal inductura is only moderately thickened and is separated from the columellar inductura by a shallow reentrant. The ephebic stage may be said to begin with the fifth whorl by the gradual assumption of the characters of the adult shell such as the groove between the gradually appearing median ventricosity and costate shoulders. At this stage the parietal inductura becomes more thickened, flattened in the plane of the aperture and merges with the columellar inductura. Some specimens show at ephebic stages transverse rugae on the parietal inductura. Ephebic conditions continue through the fifth and the first half of the sixth whorl where the shoulders with their costae tend to disappear as does the median ventri-

EXPLANATION OF PLATE 40

FIGS. 1*a–n*.—*Naticopsis scintilla* Girty. Page 374

a, *b*, The holotype (×10). A neanic individual from the Westerville limestone at Kansas City, Missouri. *c*, *d*, A topotype (×10); *e–f*, another topotype (×10). *c–f* are neanic individuals like the holotype. *g*, A topotype (×2) an early ephebic individual, the same as shown in Plate 42, figure 2*c*. *h*, A topotype (×1); *i–j*, Another topotype (×1). *k*, my largest topotype specimen (×1); *g–k* are ephebic individuals at various stages of growth. *l*, A plesiotype from the Plattsburg limestone at Ottawa, Kansas (×1). This specimen shows the transition from ephebic to gerontic stages. *m–n*, A very large gerontic individual, the holotype of *N. altonensis* var. *gigantea* Meek and Worthen (×1), apparently from the La Salle limestone at La Salle, Illinois. See also Plate 42, figure 2*c*.



Knight, Pennsylvanian gastropods

cosity. The groove, losing its boundaries as it were, also flattens out. Another gerontic change is that the line of the sutures, which are parallel, in a spiral sense, and at a very low angle with the axis of the shell for the first five and one half whorls, in the last half of the sixth whorl greatly increases the angle with the axis and passes obliquely downward across the face of the previous whorl. There seems to be little final change in the characters of the thickened inductura, though it seems to lose any transverse rugae it may have had. The neanic stages are shown on Plate 41, figure 2*a*, the ephebic figures 2*b*–*g*, and the gerontic figures 2*h*–*j*.

This species may be regarded as the direct ancestor of the two species in ascending order, *N. meeki* and of *N. scintilla* which share with it, though in different degrees of development, a number of characters such as the ephebic shouldering, with transverse costae, the median ventricosity and the revolving groove. In these two species these characters are successively less strongly developed.

The use of the name *Naticopsis ventricosa* and the synonymy given above both require some justification, particularly as I have been unable to see the types upon which the names were founded. As for the rendition of the name itself, in the original publication Norwood and Pratten describe the species as "ventricose" and render the name as *N. ventrica*. They do not give the derivation of their name but it seems obvious that it was intended to be descriptive of the striking character of the shell, its ventricosity. Now, *ventrica* is not Latin and cannot be derived from the Latin, and it seems quite evident that, as written, it is a *lapsus calami* for *ventricosa*. Meek and Worthen's correction of the *lapsus* (3b, p. 592) was quite in order, even though Meek later withdrew it (17, p. 584).

My use of Norwood and Pratten's name, as emended by Meek and Worthen, even though the species is unrecognizable as of the original publication, is based on Meek and Worthen's redescription and reillustration from the type specimen reinforced by topotypes. Both Meek (3b, p. 593) and Girty (13, p. 203) were perplexed by the seeming inconsistency of Norwood and Pratten's original illustrations with the perported type figured by the former, though why they should be perplexed is hard to see in view of the fact that Norwood and Pratten's illustrations on their Plate 9 (op. cit.) are hardly more than very poor caricatures of any of the species illustrated. The facts seem to be that the species was founded on a specimen from New Harmony, Indiana, exact locality known, loaned by Professor Cox; and that this specimen was subsequently loaned to Meek and Worthen who figured it under the amended name, *N. ventricosus*. Furthermore, the authenticity of the specimen was further enforced by two topotype specimens in Meek and Worthen's possession independently collected. If this does not constitute a valid sub-

sequent identification, it is difficult to see what would.

One has only to compare Meek and Worthen's figure of *N. ventricosus* (op. cit.) with McChesney's of *N. altonensis* (op. cit.), taking into account that there is some individual variability in relative height, as well as ontogenetic differences, to recognize that the two names are applied to the same species. My inclusion of *N. pricei* Shumard in the synonymy is again based on Meek's study of type specimens (3b, p. 592).

It seems probable that some, at least, of the steinkerns referred by various authors to *Naticopsis torta* (Meek), perhaps even including the types, belong to this species, but it seems impossible to determine with any certainty and they are, therefore, not cited.

In further confirmation of the above synonymy, it is significant that the specimens on which each name is based are all derived from about the same stratigraphic horizon though at widely separated localities.

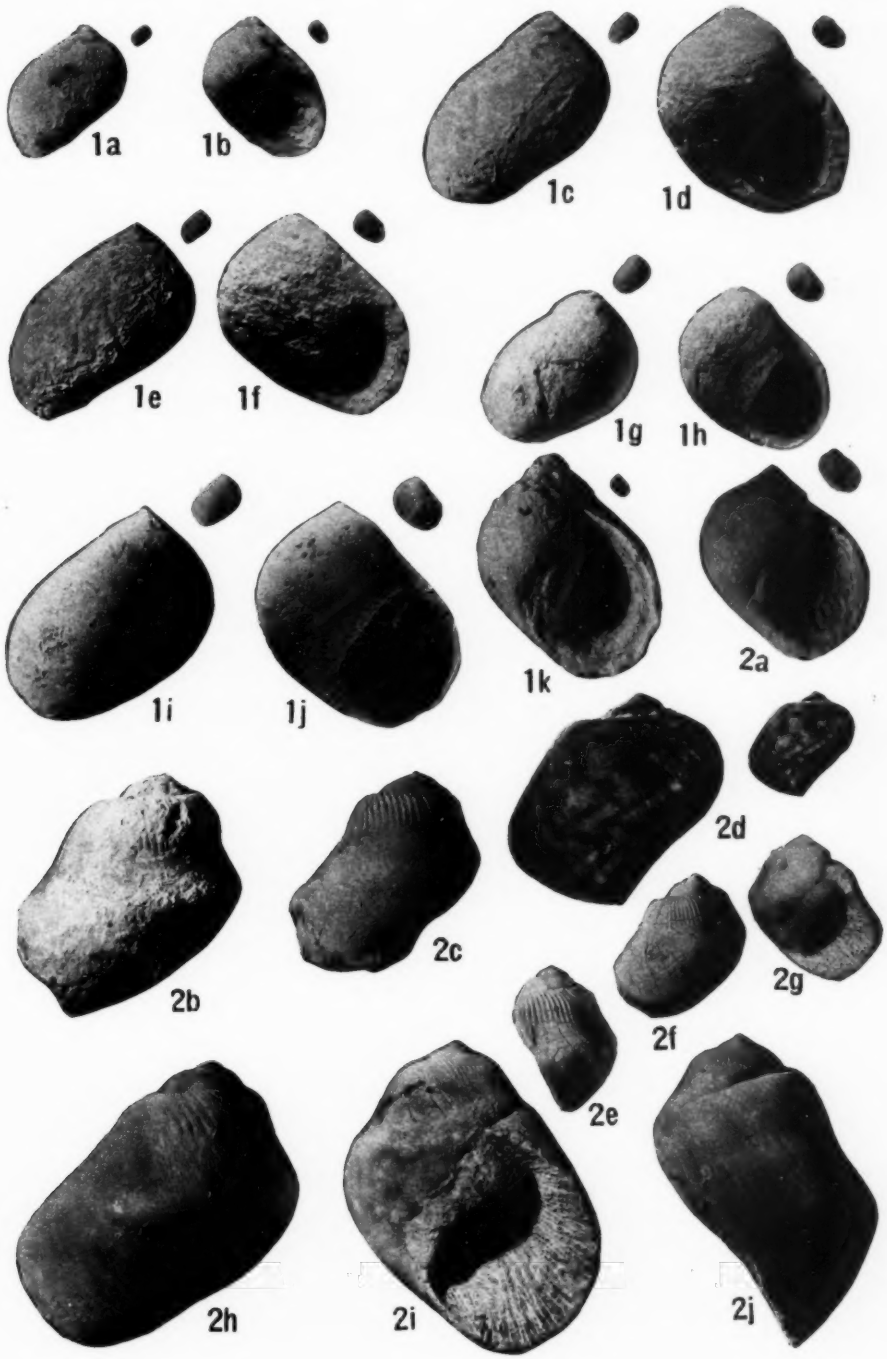
I have before me a suite of 47 specimens of all sizes from a 2-foot ledge of algal limestone outcropping in the bank of Honey Creek (SW. $\frac{1}{4}$, SW. $\frac{1}{4}$, sec. 36, T. 43, R. 27) near Garland, Henry County, Missouri, which were sent me through the kindness of Mr. John Owen of Clinton, Missouri. The exact position of this isolated ledge in the section is not known, but it is believed to be about 100 feet below the top of the Cherokee shale (12, p. 268 and p. 375, loc. $1268A_2$). I have also three specimens from the middle Boggy formation of Pontotoc County, Oklahoma (center sec. 17, T. 2 N., R. 7 E.) generally furnished me by Mr. R. V. Hollingsworth of the University of Oklahoma. My own collections from the St. Louis outlier contain four specimens from the lower Fort Scott limestone, one at Locality 7, one at Locality 10, and two at Locality 42. In addition to these I have a number of steinkerns, quite certainly of the same species from the "Chaetetes" limestone at various localities.

The Henry County specimens bear Yale Peabody Museum No. 14155; my cyrioplesiotype, No. 14154. The steinkerns from the "Chaetetes"

EXPLANATION OF PLATE 41

FIGS. 1*a–k*—*Naticopsis marthae* Knight, n. sp. Page 381
All specimens from the St. Louis, Pennsylvanian outlier. *a–b*, A paratype, a neanic individual (×6). *c–d*, A paratype, a late neanic individual (×6). *e–f*, A paratype, an early ephebic individual (×6). The specimen is somewhat corroded, particularly about the apertural margins. *g–h*, A paratype, an early ephebic individual (×4). *i–j*, The holotype, an ephebic individual (×4). *k*, A paratype, a neanic individual (×10).

2*a–j*—*Naticopsis ventricosa* (Norwood and Pratten) Page 369
All specimens are plesiotypes and all except *b* and *d*, are from near Garland, Henry County, Missouri. *b* is from the lower Ft. Scott limestone in the St. Louis, Pennsylvanian outlier and *d* is from the middle Boggy of Pontotoc County, Oklahoma. *a*, A neanic individual (×4). *b–c*, ephebic individuals (×1). *d*, an early ephebic individual photographed to show color pattern (×2). The specimen is slightly mashed from above. *e–g*, an early ephebic individual (×1). See also Plate 42, figure 2*a*, and Plate 44, figures 1*a–b*.



Knight, Pennsylvanian gastropods

limestone, No. 14159. The Oklahoma specimens bear No. 13894.

NATICOPSIS MEEKI Knight, n. sp.
Plate 42, figures 1*a–l*, 2*b*.

Moderately large, neritiform gastropods, which at adult stages have a shallow spiral groove passing around the upper half of the whorls, the groove bounded by the somewhat swollen or shouldered subsutural region, and a rounded revolving ventricosity a little below mid-whorl height; shoulders set off from the spire by only moderately deep sutures and ornamented by fine, but distinct costae, which die out below in the groove; parietal inductura thickened, somewhat flattened, and extended in the plane of the aperture, in some half-grown specimens crossed by distinct transverse rugae; color pattern, fine, closely spaced zigzag, dark, transverse bands on a lighter background.

N. meeki differs from *N. ventricosa* at the same growth stage mainly in that it is smaller and finer in every particular; its shouldering is not so strong, the costae on the shoulders are finer, the revolving groove is not so well marked and the ventricose band is rounded and not subangular. The nepionic and neanic stages are quite similar to those of *N. ventricosa* but are again very much smaller and more delicate. In spite of the above, the maximum size, of course rarely attained, seems to be quite as large as in *N. ventricosa*. My largest specimen, unfortunately too imperfect to figure, must have been fully 49 mm. high and 38 mm. wide. *N. meeki* differs from *N. scintilla* in being more strongly grooved, shouldered, and costate than that species, and in having deeper sutures. The specific name is, of course, in honor of Fielding W. Meek, perhaps the ablest paleontologist of his generation.

I have 170 specimens, one from the Pawnee limestone at Locality 33, two from the same at Locality 43, and 167 from the top of the Labette shale at Locality 43, of which 146 specimens are juveniles of less than 3 mm. in size. Dr. Norman D. Newell has loaned me a single specimen from

MEASUREMENTS OF *Naticopsis meeki*

	A	B	C	D	E
Number of whorls	6[a]	5½[b]	4½	3½	3
Height	20.25 mm.	17.25 mm.	8.5 mm.	2.85 mm.	2.1 mm.
Width	17.5 mm.	16.25 mm.	7.6 mm.	2.7 mm.	1.7 mm.
Ratio of height to width	1.15	1.06	1.12	1.09	1.23
Ratio of height of body whorl to total	0.97	0.94	0.96	0.90	0.86
Pleural angle	58°[c]	64°[c]	116°[d]	93°[d]	86°[d]

A. A paratype (Pl. 42, fig. 1*a*).
B. The holotype (Pl. 42, fig. 1*b*).
C. An early ephebic individual (Pl. 42, figs. 1*g–h*, 2*b*).
D. A neanic individual (Pl. 42, figs. 1*i–j*).
E. A neanic individual (Pl. 42, figs. 1*k–l*).

a Estimated on the assumption that 3 apical whorls are missing.
b Estimated on the assumption that 2 apical whorls are missing.
c Measured on the final whorl, shoulder to widest part.
d Measured in the usual way.

the Plattsburg limestone at the Cement Plant quarry at Bonner Springs, Kansas, that is quite confidently referred to this species. Holotype, Yale Peabody Museum, No. 14157.

NATICOPSIS SCINTILLA Girty

Plate 40, figures 1*a–n*,
Plate 42, figure 2*c*.

Naticopsis altonensis ? var *giganteus* MEEK and WORTHEN, *1873*, Geol. Survey Illinois, **5**, pl. 28, figs. 12*a-b*, Pennsylvanian, Illinois. Not *Naticopsis gigantea* Hall and Whitfield, *1872* (18, p. 20).

Naticopsis scintilla GIRTY, *1915*, Missouri Bur. Geol. and Mines, (2), **13**, p. 358, pl. 29, figs. 3–3*c;* Sayre, *1930*, Geol. Survey Kansas, **17**, p. 142, pl. 18, fig. 7, Pennsylvanian oolite, (Westerville[2]), Kansas City, Missouri.

Trachydomia pustulosa SAYRE, *1930*, op. cit., p. 152, pl. 18, fig. 3, 3a, Pennsylvanian oolite (Westerville), Muncie, Kansas.

Naticopsis pricei (SHUMARD), SAYRE, *1930*, op. cit., p. 141, pl. 18, figs. 1, 1*a*, 1*b*, Pennsylvanian oolite, (Westerville), Kansas City, Missouri.

Naticopsis altonensis (MCCHESNEY), MORGAN, *1924*, Oklahoma Bureau of Geol., **2**, pl. 49, figs. 11, 11*a*, Holdenville formation, Pennsylvanian, Stonewall quadrangle, Oklahoma.

Moderately large, neritiform gastropods, which at adult stages have a very broad, shallow and somewhat obscure spiral groove or flattening passing around the upper half of the whorls, this concave or flattened band bounded by the somewhat swollen or slightly shouldered subsutural region and a rounded ventricosity a little below mid-whorl height, shoulders set off from the spire by well marked, but not deep sutures and either without sculpture or with only a faint fasciculation of the growth lines near the suture; parietal inductura thickened, somewhat flattened and extended in the plane of the aperture.

N. scintilla differs from both *N. ventricosa* and *N. meeki* in that the revolving groove is more obscure, the shouldering of the whorls less strongly developed, the sutures shallower and in that the costae on the

[2] G. E. Condra, F. C. Greene and R. C. Moore have recently determined that the so-called Drum limestone at Kansas City is equivalent to the Westerville limestone of Iowa and should be designated by the name Westerville.

MEASUREMENTS OF *Naticopsis scintilla*

	A	B	C	D	E	F
Number of whorls	7[a]	6½[b]	6[c]	5½[c]	5[d]	3½[c]
Height	56[a] mm.	36.5 mm.	29 mm.	22 mm.	11 mm.	2.6 mm.
Width	52 mm.	34 mm.	27.5 mm.	21 mm.	11 mm.	2.7 mm.
Ratio of height to width	1.08	1.07	1.08	1.05	1.00	0.96
Ratio of height of body whorl to total	0.92	0.95	0.95	0.94	0.94	0.94
Pleural angle	90°[e]	98°[f]	92°[e]	96°[f]	85°[e]	79°[e]

A. The holotype of *N. gigantea* Meek and Worthen, a very large gerontic individual (Pl. 40, figs. 1*m–n*).
B. A plesiotype from Kansas City, a large individual (Pl. 40, fig. 1*k*).
C. A plesiotype from Kansas City, (Pl. 40, fig. 1*i–j*).
D. A plesiotype from Kansas City, of about average size, (Pl. 40, fig. 1*h*).
E. A plesiotype from Kansas City, in early ephebic stages, (Pl. 40, fig. 1*g*).
F. The holotype of *N. scintilla*, a late neanic individual (Pl. 40, figs. 1*a–b*).

a Allowing about 3 mm. for 4 lost apical whorls and broken lower margin of aperture.
b Estimated on the assumption that 4 apical whorls are missing.
c Estimated on the assumption that 2 apical whorls are missing.
d Allowing about 1 mm. for 2 lost apical whorls and broken lower margin of aperture.
e Measured in the usual way.
f Measured from shoulder to ventricosity, on final whorl.

shoulders are very weakly developed, or even entirely lacking. The shell as a whole is more rotund, is smoother and less angular than in either of the other two species. At neanic stages the spire of *N. gigantea* is noticeably higher and the sutures shallower than in the same stages of the compared species.

Through the courtesy of Professor Carey G. Croneis, of the University of Chicago, I have before me Meek and Worthen's holotype of *N. gigantea*, a splendidly preserved and very large specimen (see Plate 40, figures 1*m–n*). Meek and Worthen did not give any description of the species nor did they even state where the type was collected, omissions that were no doubt due to the fact that Meek's illness prevented his having any part in the preparation of Volume 5 of the Illinois Geological Survey, other than the preparation of the plates. The label accompanying the specimen is not the original, but a more recently typewritten one and it gives the locality as near Alton, Illinois, a statement I am inclined to question and to consider as subsequent, erroneous, and guided by the specific name applied to the form, viz. *altonensis*. The specific name used by Meek and Worthen might be taken as indicating the origin had it not been first applied by a different author to a different species that did come from Alton. The specimen has the peculiar dark-gray matrix and translucent walnut-brown color so characteristic of specimens derived from the basal, argillaceous beds of the LaSalle limestone at LaSalle, Illinois. This combination of matrix and preservation is quite characteristic of fossils from the LaSalle limestone at LaSalle and nothing like it is known from the outlier near Alton. The occurrence of the same species in the Westerville oolite at Kansas City, Missouri, and in the Plattsburg limestone of Kansas, which horizons seem to be in the same stratigraphic zone as the LaSalle limestone, lends support to this conclusion if support is needed.

The second citation in the synonymy, *N. scintilla* Girty, thus bringing together under one name what have been thought to be the largest and the smallest species of *Naticopsis* described from the American Pennsylvanian, will no doubt be as startling to the reader as it was to me when the study of a series of growth stages in topotype specimens of *N. scintilla*, forced me to that conclusion. Dr. G. H. Girty has been kind enough to put at my disposal the tiny holotype of *N. scintilla*, and so long as intermediate growth stages are lacking nothing could be more different than this specimen and the type of *N. gigantea*. Thanks to Prof. C. O. Dunbar, I have at my disposal a collection of naticopsids from the Westerville oolite at Kansas City, Missouri, the bed and locality from which the types of *N. scintilla* were derived. The specimens of this collection show complete gradation in size and other characters from that shown as figures 1*c–d*, Plate 40 to that shown as figure 1*k* on the same plate. Another collection of the same species, loaned me by Dr. Norman

Newell, and collected at several places in Kansas, from the Plattsburg limestone only a little higher in the section, furnished, among other specimens, one (see Plate 40, figure 1*l*) that was somewhat larger than my largest Kansas City specimen, and which had begun to take on the gerontic characters that, until then unrecognized as such, seemed to set the type specimen of *N. gigantea* apart as unique. The chain was then complete and it seems necessary to regard *N. scintilla* and *N. gigantea* as synonymous.

Although the name *gigantea*, proposed by Meek and Worthen as a varietal name, has priority over the specific name *scintilla* Girty, and, since varietal and specific names are nomenclatorially of equal rank, would ordinarily be employed instead of the latter, the former comes in conflict with *N. gigantea* Hall and Whitfield proposed in the previous year for a Devonian form (18, p. 20). Thus, since the term *N. gigantea* Meek and Worthen must be suppressed as a homonym, *N. scintilla* Girty, its oldest valid synonym, must take its place.

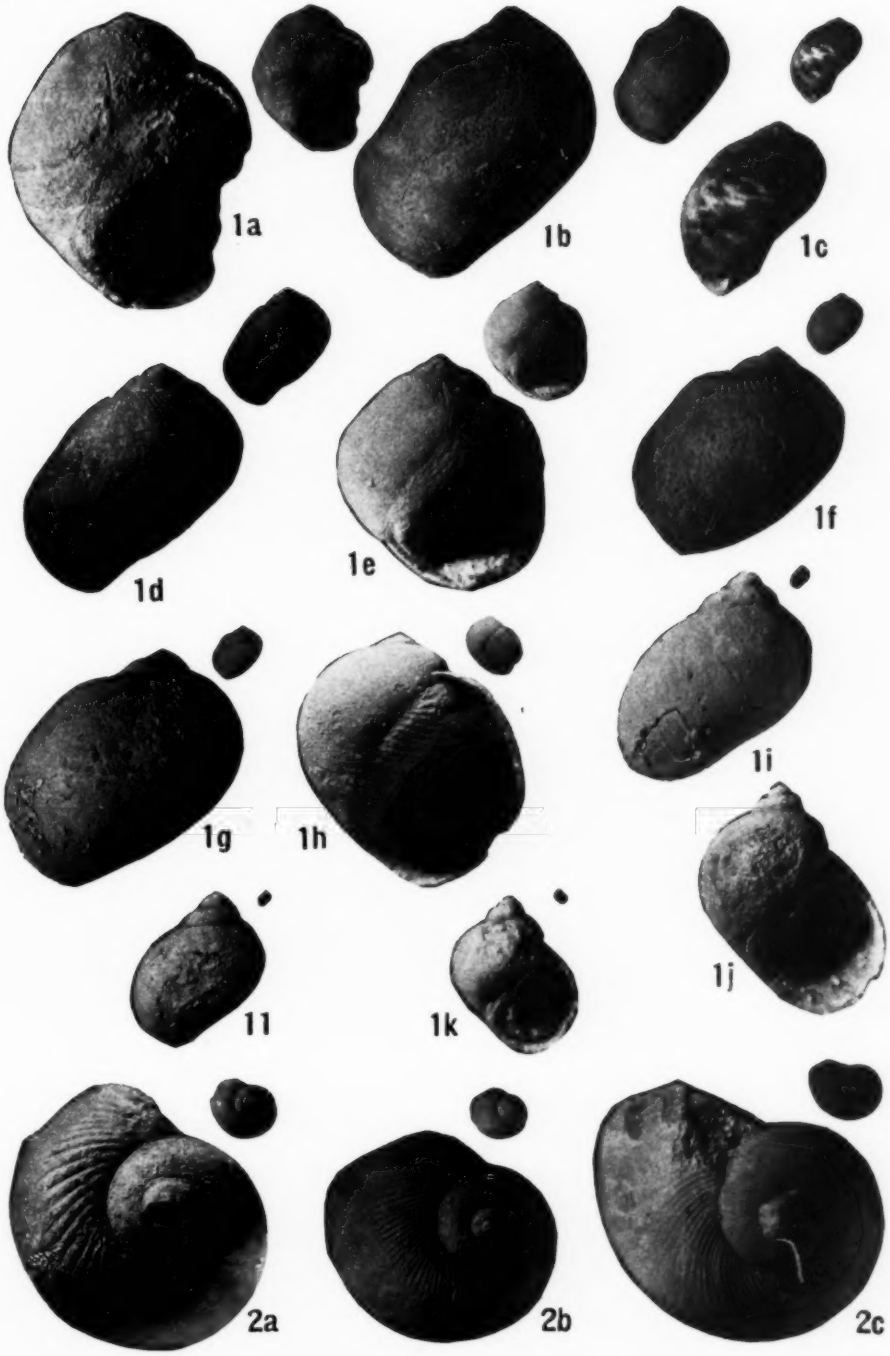
Trachydoma pustulosa Sayre, the holotype of which I have before me through the courtesy of Professor Raymond C. Moore of the University of Kansas, is simply a corroded specimen of *N. scintilla*, as one would suspect from a study of Sayre's figure (op. cit.) and a comparison of it with his figure of *N. pricei* Sayre (not Swallow), also a synonym, on the same plate (op. cit.). It will be noted that this species seems to be confined to a zone in the Pennsylvanian that includes the LaSalle limestone in Illinois, the Kansas City and lower Lansing group in Kansas and the Holdenville formation in Oklahoma.

I have before me the holotype of *N. gigantea* Meek and Worthen from Illinois, almost certainly from the LaSalle limestone at LaSalle, 16 topotypes from the oolite at Kansas City, Missouri, six of which (including the holotype of *N. scintilla*) are very small, two specimens from the Plattsburg limestone (Spring Hill member) 15 miles northwest of Kansas City, Kansas, one from the same horizon at about 10 miles east of Ottawa, Kansas, and another from the same horizon near Gardner, Kansas.

EXPLANATION OF PLATE 42

FIGS. 1*a–l*—*Naticopsis meeki* Knight, n. sp. Page 373
All specimens from the St. Louis, Pennsylvanian outlier. *a*, Apertural view of a large paratype, an ephebic individual (×2). *b*, The holotype (×2). *c*, A paratype retaining its color markings (×2). *d–e*, A paratype, ephebic (×2). *f* and *g–h*, two paratypes, early ephebic (×4). Figure 2*b*, this plate, is the same specimen as *g–h*. *i–j* and *k–l*, Two paratypes, neanic individuals (×10).

2*a–c*—Views of early ephebic specimens of three species of the group of *N. ventricosa* to show in comparison the characteristic sculpture of each. (All ×4.)
a, *N. ventricosa* (Norwood and Pratten) Page 369
b, *N. meeki* Knight, n. sp. Page 373
c, *N. scintilla* Girty Page 374
The shallower sutures of the last species, as compared with those of the other two, are also well known.



Knight, Pennsylvanian gastropods

The holotype of *N. gigantea*, Meek and Worthen, Walker Museum, University of Chicago, No. 10626.

The holotype of *N. scintilla* Girty, U. S. Geol. Survey, No. 2906, Washington, D. C.

Yale Kansas City specimens, Yale Peabody Museum, Nos. 14151, 14152 and 14153.

NATICOPSIS PULCHELLA Morningstar

Plate 44, figure 3.

Naticopsis pulchella MORNINGSTAR, *1922*, Geol. Survey Ohio, (4), **25**, pp. 256–257, pl. 15, fig. 16, lower Mercer black shale, Pennsylvanian, Stark County, Ohio.

I shall not redescribe this species, as the holotype and only specimen is too fragmentary to warrant saying more than that it seems to be the earliest named species from the American Pennsylvanian of the low-spired series of forms that include *N. wortheni* Knight, n. sp. and *N. subovata* Worthen. Indeed it seems to have a much lower spire and to be more explanate than either of the other two. Its color banding is beautifully preserved and an attempt is made to show the revolving pattern of dark and light bands.

The specimen suggests in some respects a closely coiled platyceratid, but the well formed, thickened columella negatives the suggestion.

It is hoped that the species will be redescribed from better preserved, topotype material.

The holotype was loaned me through the courtesy of Professor J. E. Carman of the Ohio State University. It bears the Number 15,311 O.S.U.

NATICOPSIS WORTHENI Knight, n. sp.

Plate 43, figures 3*a–k*

Small, explanate, naticiform gastropods, which at adult stages have a very low spire and very large body whorl; sutures shallow; whorl profile evenly rounded; outer lip thin; columellar lip and parietal wall covered with moderately thickened inductura, not greatly extended or flattened in the plane of the aperture; inductura crossed by faint transverse rugae at early adult stages; ornamentation, other than growth lines generally lacking, but an occasional specimen shows fasciculation of the growth lines near the upper suture; nucleus quite small, smooth, simple and dextral; color pattern known

MEASUREMENTS OF *Naticopsis wortheni*

	A	B	C	D
Number of whorls	5½[a]	5[a]	4½[a]	2½
Height	15 mm.	8.7 mm.	7.0 mm.	1.4 mm.
Width	14.5 mm.	8.0 mm.	6.0 mm.	1.4 mm.
Ratio of height to width	1.03	1.08	1.16	1.00
Ratio of height of body whorl to total	0.97	0.95	0.96	0.93
Pleural angle	118°	120°	121°	110°

A. The holotype, and largest specimen (Pl. 43, fig. 3*j–k*).
B. A paratype (Pl. 43, fig. 3*h–i*).
C. A paratype (Pl. 43, fig. 3*f–g*).
D. A paratype, a neanic individual (Pl. 43, fig. 3*d–e*).

[a] Estimated on the assumption that 3 apical whorls are missing.

only from juvenile specimens, light-chestnut and white revolving bands, a narrow white band next the suture, followed by a narrow chestnut band, another narrow white, but broader than the first, a rather broad chestnut band, a narrow white, another broad chestnut and a final, circumumbilical, white band.

The ontogenetic change in this species is from a rather naticoid neanic stage with relatively high spire and deep sutures to an ephebic form with lower spire and shallower sutures. The only gerontic character noted on the holotype and largest specimen is the increased slope of the suture in the last quarter whorl.

N. wortheni is very close to *N. subovata* Worthen, but may be differentiated by the careful worker by the fact that it does not show the rounded ventricosity which is developed on the whorls of the latter species a little above mid-whorl height. The curve of the parietal and columellar border of the aperture of *N. wortheni* is rather straight in the parietal region and joins to the columellar lip with a slight angle while the same two characters of *N. subovata* form together almost a smooth crescent. The spire of *N. wortheni* is also slightly more elevated. *N. wortheni* lacks the lateral flattening of the upper half of the final whorl of *N. virgata* Knight, n. sp. While we do not know much relative to details of form in *N. pulchella* Morningstar, *N. wortheni* is not so greatly flattened as that species seems to be, is much smaller for the same number of whorls and shows, at young stages, a similar color pattern but with different details. *N. wortheni* may also be differentiated from *N. subovata* by the very different color pattern, if preserved.

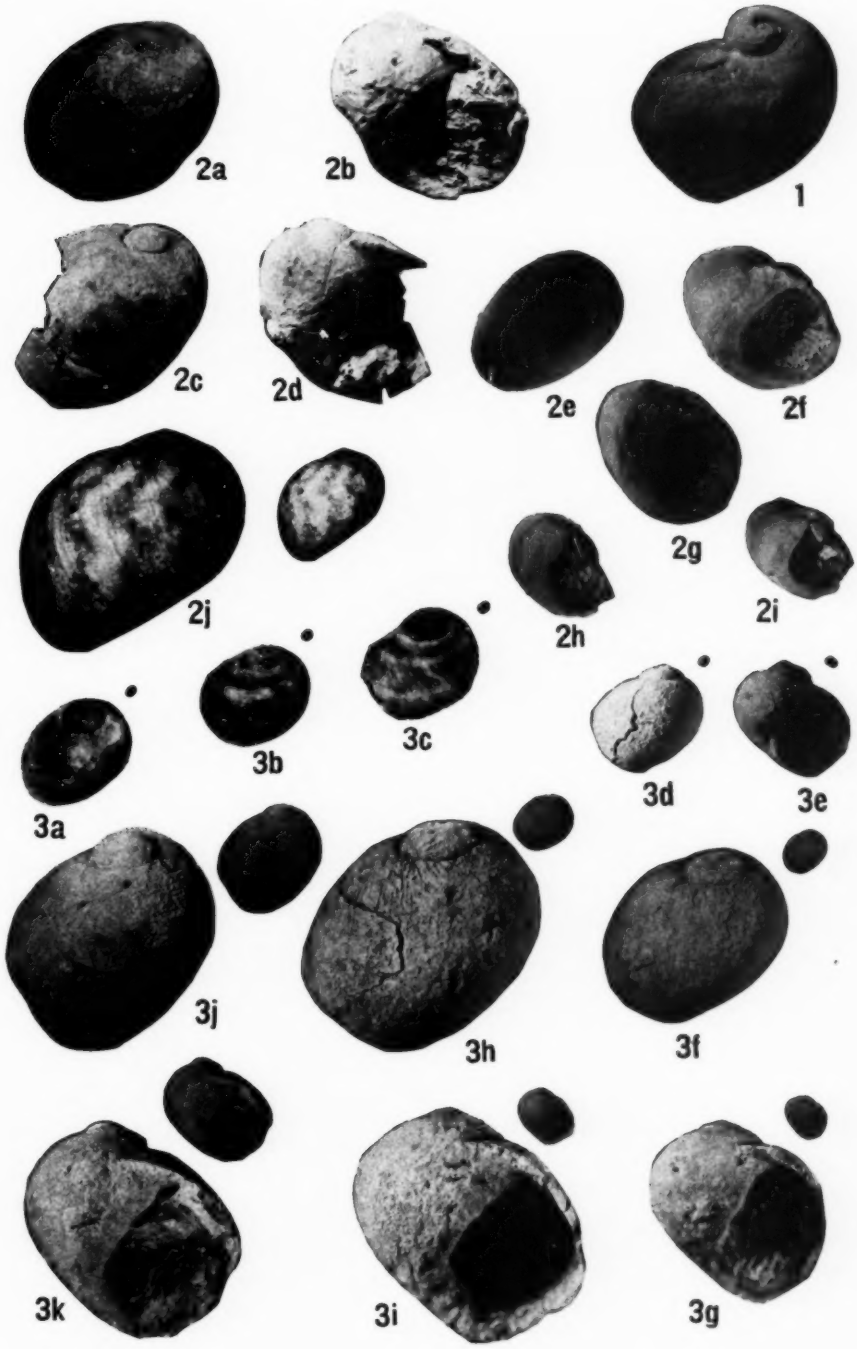
I have 22 specimens from the top of the Labette shale at Locality 43, fourteen of which are juveniles. It is most abundant in Zone R though two of the juveniles are from Zone G. A single small specimen, from the base of the Pawnee limestone at Locality 6, is referred to the species. Holotype, Yale Peabody Museum, No. 14158.

EXPLANATION OF PLATE 43

FIG. 1—*Naticopsis peoriensis* (McChesney) Page 367
A sulphur cast of the holotype, itself a steinkern (×1).

2*a–j*—*Naticopsis subovata* Worthen Page 379
a–b, The holotype (×1), from the La Salle limestone of Illinois. *c–i*, Plesiotypes from the Vilas shale, Anderson County, Kansas, (×1). *c–d*, A large specimen, comparable with the holotype in size. *e–g*, A smaller specimen, *e*, dorsal view vertical orientation, *f*, apertural view, axis vertical, *g*, apertural view, specimen tipped back to show cycle-like sweep of the thickened inductura. *h–i*, Apertural views of a small specimen, *h* tipped back, *i*, vertical. *a* and *c* are not vertical, but lie with the plane of the aperture in the plane of the plate. *j*, A specimen from Kansas City, Missouri, photographed to show color pattern (×2).

3*a–k*—*Naticopsis wortheni* Knight, n. sp. Page 377
All specimens from the St. Louis, Pennsylvanian outlier. *a–c*, Three early neanic individuals (paratypes) showing color marking (×10). *d–e*, an early neanic individual (paratype) to show form at this stage of growth (×10). This is the same specimen shown as fig. 3*b*. *f–i*, Two ephebic individuals paratypes, (×4). *j–k*, The holotype, (×2). *f*, *h* and *j* are orientated with the plane of the aperture in the plane of the plate.



Knight, Pennsylvanian gastropods

NATICOPSIS SUBOVATA Worthen

Plate 43, figures 2*a–j*

Naticopsis subovatus WORTHEN, *1873*, Geol. Survey Illinois, 5, p. 595, pl. 28, fig. 9, Pennsylvanian, La Salle, Illinois. Not *N. subovatus* MORGAN, *1924*.

Moderately large, explanate naticiform gastropods, which at adult stages have a very low spire and very large body whorl; sutures shallow; whorl profile evenly rounded but slightly ventricose just above the middle and very slightly flattened above; outer lip thin; columellar lip and parietal wall covered with a moderately thickened inductura, not greatly extended or flattened in the plane of the aperture; apparently no ornamentation; color pattern broad, zigzag transverse bands of dark pigment on a lighter background; nucleus not observed, but probably similar to the same characters in *N. wortheni* Knight, n. sp.

All of the specimens before me are in ephebic growth stages, and none of them show any marked gerontic characters. The differentiation of this species from *N. wortheni* is discussed under that species.

It is probable, but not certain that *N. peoriensis* (McChesney), 1860, belongs to this species, but, since that species is based on a steinkern, and since its exact horizon in the long Peoria section is unknown, it seems advisable to let McChesney's name lapse into oblivion. If the synonymy is established, McChesney's name will, of course, take priority.

I have before me, through the courtesy of Prof. T. E. Savage, of the University of Illinois, Worthen's holotype. Dr. R. S. Bassler, of the U. S. National Museum, has also permitted me to examine two topotype specimens in the Rominger Collection, No. 36434. Four specimens in the Peabody Museum collections at Yale (No. 13895) are labelled as having been collected from the Chanute shale, on Turkey Creek, Kansas City, Missouri. Dr. Norman D. Newell has been generous enough to lend me some 86 specimens from the Vilas shale, Lansing group (10, table c, op. p. 18), at several points in Kansas. Of the latter, eight specimens were collected from a large quarry on the main highway two miles north of Garnett and some 78 are from the railroad quarry in the center of the

MEASUREMENTS OF *Naticopsis subovata*

	A	B	C	D
Number of whorls	5½[a]	5½[a]	5[a]	5¼[a]
Height	26.5 mm.	25 mm.	16.0 mm.	19.0 mm.
Width	26.5 mm.	26 mm.	16 mm.	20.5 mm.
Ratio of height to width	1.00	0.97	1.00	0.94
Ratio of height of body whorl to total	0.95	0.97	0.97	0.90
Pleural angle	123°	129°	135°	138°

A. The holotype (Pl. 43, fig. 2*a–b*).
B. A plesiotype (Pl. 43, fig. 2*c–d*).
C. A plesiotype (Pl. 43, fig. 2*e–g*).
D. A plesiotype (Pl. 43, fig. 2*h–i*).

[a] Estimated very roughly since the collections contain no specimens with the earliest several whorls preserved.

SW. ¼, sec. 11, T. 20 S., R. 19 E., Anderson County. Mr. Newell's specimens will be deposited at the University of Kansas.

NATICOPSIS VIRGATA Knight, n. sp.
Plate 44, figures 6 *a–g*

Small, neritiform gastropods, with low spire and rapidly increasing whorls; sutures shallow; profile of earlier whorls strongly arched but final half whorl in gerontic individuals laterally flattened for its upper two-thirds; outer lip thin; columellar lip and parietal wall with greatly thickened inductura, which is especially thickened in the posterior angle of the aperture; ornamentation, faint growth-lines only; nucleus low, simple, dextral and rather large; color markings, three subequal dark, revolving bands on a lighter background.

This species, seemingly one of a line of descent that includes *N. shumardi* McChesney, is, in a sense, intermediate in form between the group of *N. subovata* and the group of *N. ventricosa*. In its neanic growth stages it is notably flat and low spired. At early ephebic stages it is as notably globular while the lateral flattening of the upper part of the final whorl that is so marked at gerontic stages begins to put in its appearance at the mid-ephebic stage. At gerontic stages the flattening of the upper two-thirds of the final whorl, from the suture down, is so marked that, coupled with the gerontic increase of the sutural angle, the shell has almost an elongated shape. *N. virgata* is thought to be closely related to *N. shumardi* McChesney, from the La Salle limestone at La Salle, Illinois, but it is a smaller species and the final whorl seems never to be so greatly flattened and elongated as in that species.

MEASUREMENTS OF *Naticopsis virgata*

	A	B	C	D
Number of whorls	3¾[a]	3½[b]	3¼[b]	2
Height	11.5 mm.	8 mm.	7 mm.	.85 mm.
Width	10.25 mm.	7.25 mm.	6.5 mm.	1.10 mm.
Ratio of height to width	1.09	1.10	1.08	.77
Ratio of height of body whorl to total	0.96	0.97	0.95	0.98
Pleural angle	[c]	[c]	[c]	170°[d]

A. The holotype, and largest specimen, (Pl. 44, fig. 6*c–d*).
B. A paratype (Pl. 44, fig. 6*g*).
C. A paratype (Pl. 44, fig. 6*e–f*).
D. A paratype, a neanic individual (Pl. 44, fig. 6*a*).

a On the assumption that about 2 apical whorls are missing.
d On the assumption that about 1 apical whorl is missing.
c Unable to measure this because of gerontic flattening of body whorl.
d Estimated.

I have 19 specimens from the top of the Labette shale, Zone R, at Locality 43. Yale Peabody Museum, No. 14160.

NATICOPSIS SHUMARDI (McChesney)
Plate 44, figures 5*a–d*

Natica shumardi, MCCHESNEY, *1860*, Descr. New Paleoz. Foss., p. 62, *1865*, Illust. New Spec. Foss., pl. 2, figs. 15*a–b*. Pennsylvanian, La Salle, Illinois.

Through the courtesy of Dr. Carey G. Croneis, of the University of Chicago, I have before me an excellent sulphur cast of the holotype (No. 36,434) of this species, while Dr. R. S. Bassler of the U. S. National Museum has made available to me, not only another cast of the holotype (No. 62,527), but a topotype specimen in the Rominger collection (No. 36,434, part). The earlier whorls of both specimens are broken away but there can be little doubt from the characters shown by the final whorls that the species is similar in a general way to *N. virgata* Knight, n. sp. and is to be regarded as its direct descendant. The earlier ontogenetic stages are, of course, unknown, except by analogy, but in its gerontic stage this species appears to differ from *N. virgata* in its larger size and even more strongly flattened whorls.

The species is at present known only from the La Salle limestone, at La Salle, Illinois.

NATICOPSIS MARTHAAE Knight, n. sp.
Plate 41, figures 1*a–k*

Small, suboval, neritiform gastropods, with a smoothly conical spire and shallow sutures; whorl profile evenly rounded; outer lip thin at its margin, but thickening within, rather rapidly; columellar lip and parietal wall with thickened inductura, which in the parietal region may be crossed obliquely by transverse rugae; ornamentation of very fine growth-lines only; nucleus rather high spired, smooth, simple and dextral; color pattern unknown.

My largest specimen of this beautiful little species has rugae on the parietal inductura such as seem to be developed only in ephebic growth stages of the other species with which I am familiar. This suggests, then, that the gerontic and perhaps the late ephebic growth stages are not represented in my collections. *N. marthaae* is characterized by its smooth, conical spire, and by the fact that the outer lip bends backward rather markedly in the region of the excurrent groove at the suture. At neanic stages the outer lip is remarkably thickened just within the margin.

This species is named for my daughter, Martha, and the next to be described for my daughter, Judith, both of whom have often helped me collect.

MEASUREMENTS OF *Naticopsis marthaae*

	A	B	C	D
Number of whorls	4¼	3½[a]	3¼	2½
Height	7.75 mm.	5.25 mm.	4.8 mm.	2.85 mm.
Width	7.0 mm.	5.00 mm.	4.35 mm.	2.65 mm.
Ratio of height to width	1.11	1.05	1.11	1.08
Ratio of height of body whorl to total.	0.93	0.93	0.93	0.94
Pleural angle	118°	95°	103°	110°

A. The holotype and largest specimen (Pl. 41, fig. 1*i–j*).
B. A paratype (Pl. 41, fig. 1*g–h*).
C. A paratype (Pl. 41, fig. 1*e–f*).
D. A paratype, a juvenile individual (Pl. 41, fig. 1*a–b*).

a Assuming about 2 apical whorls to be missing.

I have 17 specimens referred to this species, all from the top of the Labette shale at Locality 43. It seems to be represented in both Zone G and R.

Holotype, Yale Peabody Museum No. 14156

NATICOPSIS JUDITHAE Knight, n. sp.

Plate 44, figures 7*a–d*

Small, subfusiform gastropods, with spire relatively high and sutures relatively deep for the genus; whorl profile evenly arched; outer lip thin; columellar lip somewhat thickened; parietal inductura thickened, and in some specimens crossed by transverse rugae; ornamentation lacking; nucleus high, simple and dextral; color pattern unknown.

This small species shows several remarkable characters for a member of the genus *Naticopsis* the most striking of which is the relatively high spire. Yet the aperture is typically naticopsoid in every detail and it seems necessary to include it in *Naticopsis*. I have constantly born in mind the danger of founding a species on juvenile specimens, particularly in a genus where each ontogenetic stage is so different from the others, but the specimen shown as figure 7*c–d*, Plate

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EXPLANATION OF PLATE 44

FIGS. 1 *a–b*—*Naticopsis ventricosa* (Norwood and Pratten) Page 369
Two steinkerns referred to this species from the "Chaetetes limestone" of the St. Louis outlier (×1). These are figured for comparison with figure 2, this plate.

2—*Naticopsis torta* (Meek) Page 367
A copy of one of Meek's figures, reproduced for comparison with the naticopsid steinkerns shown as 1*a–b*, this plate. There can be little doubt that Meek founded this name on steinkerns and that it is impossible to identify the species with any other, though it probably belongs to the group of *N. ventricosa*.

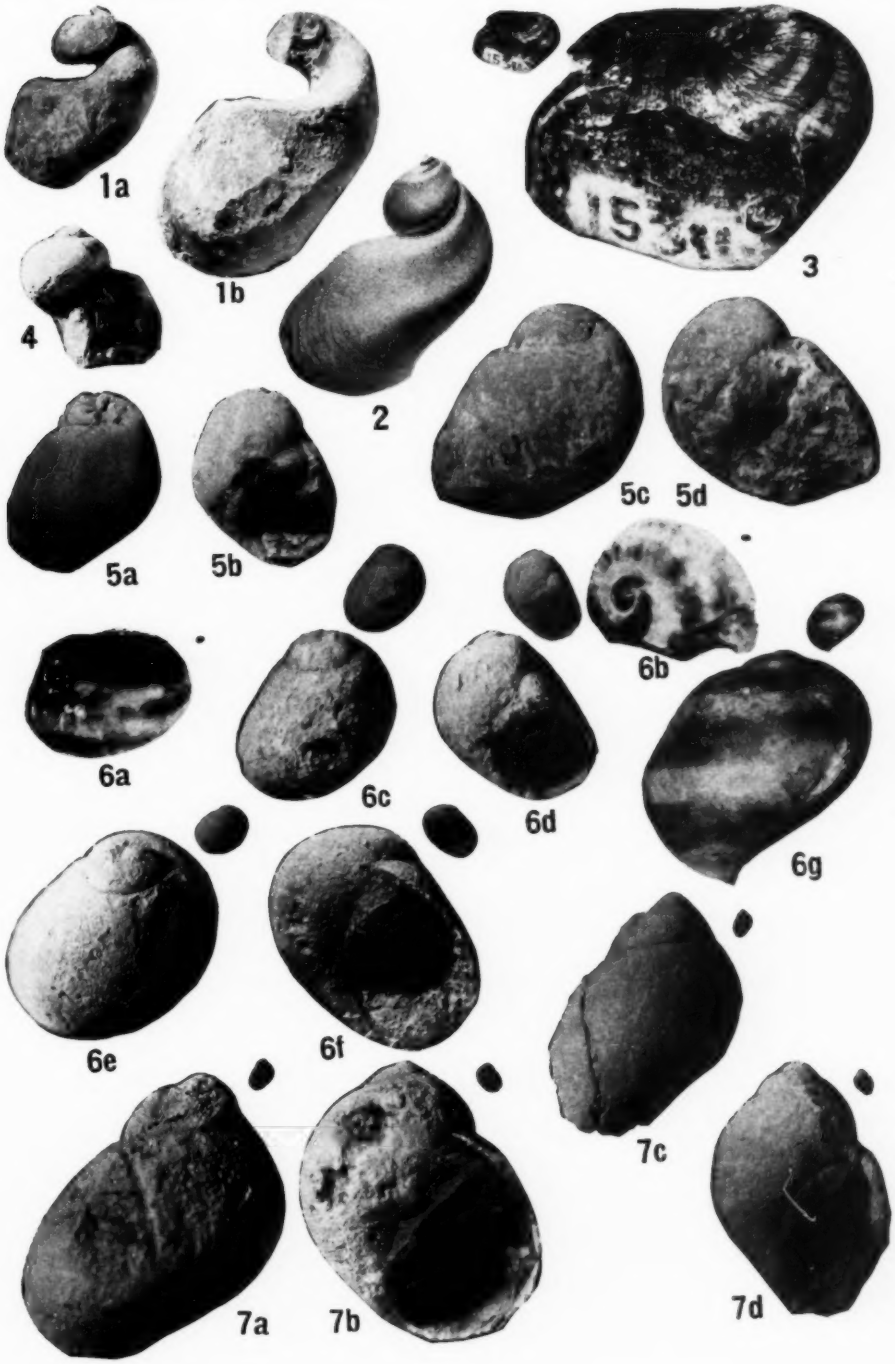
3—*Naticopsis pulchella* Morningstar Page 377
The holotype (×4). Photographed so as to show the color-markings.

4—*Naticopsis remex* White Page 367
The holotype (×1). This species, like *N. torta* (Meek), is founded on a steinkern and is likewise not identifiable.

5*a–d*—*Naticopsis shumardi* (McChesney) Page 380
Both specimens (×1) from the La Salle limestone at La Salle, Illinois. *a–b*, A sulphur cast of the holotype. *c–d*, A topotype specimen. Note the flatness of the upper two-thirds of the final whorl and the elevated face of the whorl next above.

6*a–g*—*Naticopsis virgata* Knight, n. sp. Page 380
All specimens from the St. Louis Pennsylvanian outlier. *a–b*, Two early neanic individuals (paratypes) to show low flattened spire at this stage and the color-banding (×20). *c–d*, the holotype, an ephebic (possibly gerontic?) individual (×2). *e–f*, An ephebic individual (a paratype) somewhat younger than the preceding (×4). *c* and *e* are orientated with the plane of the aperture in the plane of the plate, *d* and *f* are vertical. *g*, An early ephebic individual (a paratype) photographed to show color marking (×4). Note that in this specimen the side to the right shows the rounded whorl profile of neanic stages, while that to the left shows the first stages of ephebic flattening.

7*a–d*—*Naticopsis judithae* Knight, n. sp. Page 382
Both specimens (×10) from the St. Louis Pennsylvanian outlier. *a–b*, The holotype, seemingly an ephebic, if not gerontic, individual. *c–d*, A younger, ephebic individual (a paratype). Note the transverse rugae on the parietal inductura.



Knight, Pennsylvanian gastropods

MEASUREMENTS OF *Naticopsis judithae*

	A	B
Number of whorls	5[a]	4
Height	4 mm.[a]	3.2 mm.
Width	3.5 mm.	2.5 mm.
Ratio of height to width	1.24	1.38
Ratio of height of body whorl to total	0.92	0.91
Pleural angle	76°	69°

The holotype and largest specimen (Pl. 44, fig. 7*a-b*).
A paratype (Pl. 44, fig. 7*c-d*).

a Assuming that 3 apical whorls are lost.

44, although only 3.2 mm in height, already shows transverse rugae on its thickened parietal inductura and, as stated previously, I have met this character only on specimens in the ephebic growth-stage. Furthermore, the largest specimen, the holotype, seems to be gerontic, though, indeed there seem to be gerontic characters in this species from the earliest stages. I refer particularly to the low position of the suture on the whorl face.

All of my 17 specimens are from Zone G, at the top of the Labette shale at Locality 43.

Genus TRACHYDOMA Meek and Worthen, 1866

TRACHYDOMA NODOSUM (Meek and Worthen)

Plate 45, figures 2*a–i*

Naticopsis nodosus MEEK and WORTHEN, *1860*, Proc. Acad. Nat. Sci., Philadelphia, p. 463, Pennsylvanian, St. Clair Co., Illinois.

Naticopsis holidayi MEEK and WORTHEN, *1860*, Proc. Acad. Nat. Sci., Philadelphia, p. 463, Pennsylvanian, Hodge's Creek, Macoupin County, Illinois.

Naticopsis (*Trachydomia*) *nodosa* MEEK and WORTHEN, *1866*, Geol. Survey Illinois, **2**, p. 366, pl. 31, figs. 2*a*, *b*, Pennsylvanian, St. Clair County, Illinois.

Naticopsis (*Trachydomia*) *nodosa* var. *hollidayi* MEEK and WORTHEN, *1866*, Geol. Survey Illinois, **2**, p. 367, pl. 31, figs. 3*a*, *b*. Pennsylvanian, Hodges Creek, Macoupin County, Illinois.

Moderately large gastropods with the general characters of the genus. Within the genus, the species is characterized by rather coarse nodes or pustules and a ratio of height to width of generally less than one to one. The subsutural smooth area is not deeply channeled. The topmost row of pustules not much stronger than the others and with a tendency for the

MEASUREMENTS OF *Trachydoma nodosum*

	A	B	C	D	E
Number of whorls	5¾[a]	5¼[a]	5⅜[a]	5[a]	4
Height	27 mm.	21.5 mm.	23 mm.	17 mm.	8 mm.
Width	29 mm.	22.5 mm.	23 mm.	18 mm.	7 mm.
Ratio of height to width.	0.94	0.96	1.00	0.95	1.14
Ratio of height of body whorl to total	0.89	0.89	0.89	0.91	0.85
Pleural angle	100°	104°	96°	100°	90°

A. A large individual, the holotype of *N. hollidayi* Meek and Worthen (Pl. 45, fig. 2*a–b*).
B. The holotype of *N. nodosus* Meek and Worthen (Pl. 45, figs. 2*c–d*).
C. My cyrioplesiotype (Pl. 45, figs. 2*e–f*).
D. A plesiotype (Pl. 45, figs. 2*g*).
E. An early, ephebic individual (Pl. 45, figs. 2*i*).

a Estimated on the assumption that 2 apical whorls are missing.

pustules of the topmost row to fuse with those of the row next below at late growth stages.

T. nodosum resembles most closely *T. newelli*, but differs in being relatively wider, in its pustules being not quite so large and with less tendency for them to fuse into coarse, crenulated rows, and most markedly in that the collar-like area without pustules next the suture is not so conspicuously depressed or channeled. Young specimens are rather similar to adults of *T. sayrei* and *T. whitei* but the pustules are somewhat coarser and more widely spaced than in the former, while in the latter the subsutural smooth band is flatter and the shoulder-pustules bordering it are more prominent.

The holotype, which I have before me, was collected in St. Clair County, Illinois, directly across the Mississippi River from St. Louis and probably from the Piasa (Pawnee) limestone in which it is so abundant[3] as to be one of its most conspicuous fossils.

I have, besides Meek and Worthen's types, 73 specimens of this species, 60 of them from the lower part of the Pawnee limestone at Localities 6, 43 and 53. Eight specimens are from the top of the Labette shale at Locality 43, and 5 specimens from the lower Fort Scott limestone at Localities 7, 10, 21 and 42.

Cyrioplesiotype, Yale Peabody Museum, No. 14162.

[3] In describing this limestone in the St. Louis area (15, p. 45) I inadvertantly applied the name *T. nodulosa* to this species, an error I take this opportunity to correct.

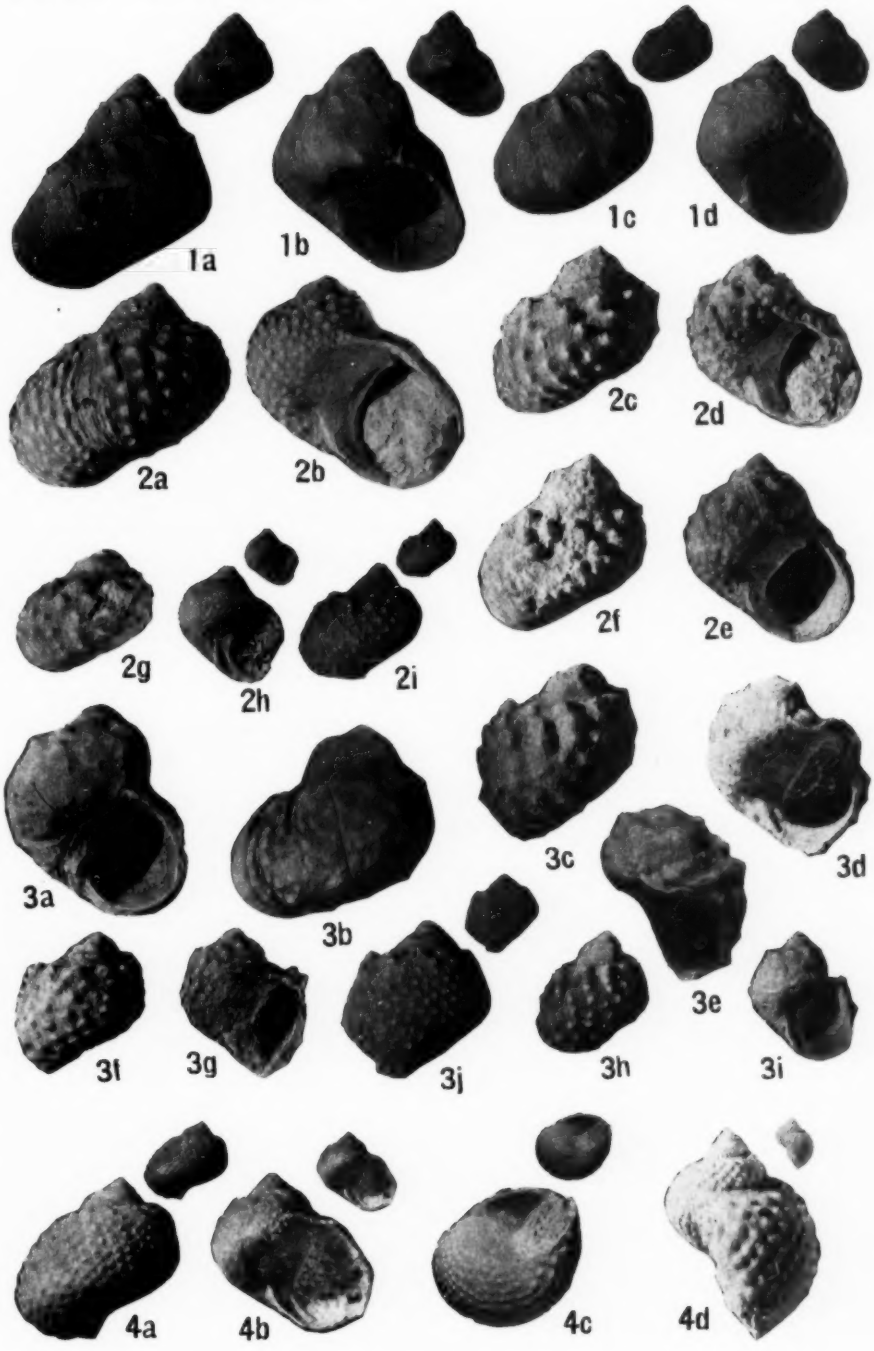
EXPLANATION OF PLATE 45

FIGS. 1*a–f*—*Turbonitella biserialis* (Phillips) Page 364
The genotype of *Turbonitella* de Koninck.
These photographs of Belgian Mississippian specimens of this hitherto inadequately illustrated species, are introduced to show the close affinity of the genus to *Trachydoma* Meek and Worthen. Figures (×2).
Specimens from de Koninck collection at the Museum of Comparative Zoology, Harvard, through the courtesy of Professor P. E. Raymond.

2*a–i*—*Trachydoma nodosum* (Meek and Worthen) Page 383
The genotype of *Trachydoma* Meek and Worthen.
a–b, The holotype of *T. hollidayi* (Meek and Worthen) (×1). A large gerontic individual from Hodges Creek, Macoupin County, Illinois. *c–d*, The holotype of *T. nodosum* (Meek and Worthen), from St. Clair County, Illinois (×1). *e–i*, Plesiotypes from the Pawnee limestone of the St. Louis outlier, showing different growth stages. *e*, *f*, and *g* (×1); *h* and *i* (×2).

3*a–j*—*Trachydoma newelli* Knight, n. sp. Page 385
All specimens from the Vilas shale, Anderson County, Kansas.
a–b, A large gerontic individual a paratype. The shell is badly corroded and has lost all details of its surface ornamentation (×1). *c–e*, The holotype, a late ephebic individual (×1). *f–i*, Two ephebic individuals, paratypes, at different growth stages (×1). *j*, An early ephebic individual, a paratype, (×2).

4*a–d*—*Trachydoma sayrei* Knight, n. sp. Page 385
All specimens from the Westerville oolite at Kansas City, Missouri.
a, The holotype, an ephebic individual (×2). *b*, A paratype, an ephebic individual (×2). *c*, The holotype, basal view (×2). *d*, A paratype, an early ephebic individual (×4). The third whorl of this specimen shows transverse lirae much like those of *Natiria*.



Knight, Pennsylvanian gastropods

MEASUREMENTS OF *Trachydoma newelli*

	A	B	C	D
Number of whorls	6[a]	5¾[a]	5½[a]	5[b]
Height	29.0 mm.	26.0 mm.	20.0 mm.	16.5 mm.
Width	28.0 mm.	21.5 mm.	16.5 mm.	13.5 mm.
Ratio of height to width	1.03	1.21	1.21	1.22
Ratio of height of body whorl to total.	0.86	0.92	0.90	0.91
Pleural angle	96°[c]	96°[c]	106°[c]	103°[c]

A. A paratype, the largest specimen, somewhat gerontic (Pl. 45, fig. 3*a–b*).
B. The holotype (Pl. 45, fig. 3*c–e*).
C. A paratype (Pl. 45, fig. 3*f–g*).
D. A paratype, half grown (Pl. 45, fig. 3*h–i*).

a Estimated on the assumption that 4 apical whorls are missing.
b Estimated on the assumption that 1 apical whorl is missing.
c Because of the strong, noded shoulder, this value is very difficult to obtain. The figures are only approximate.

TRACHYDOMA NEWELLI Knight, n. sp.

Plate 45, figures 3*a–j*

Moderately large gastropods with the general characters of the genus. Within the genus, the species is characterized by very coarse nodes or pustules and a ratio of height to width of somewhat more than one to one. The subsutural smooth area is notably concave and channeled. The uppermost row of pustules is quite prominent and there is a marked tendency for the pustules to coalesce into coarse, transverse, crenulated ridges at late growth-stages.

T. newelli resembles most closely *T. nodosum* but differs in its relatively greater height, its notably channeled subsutural nodeless band and its larger pustules, tending at gerontic stages to coalesce into coarse, crenulated transverse ridges. The lower half of the body whorl in *T. newelli* is also somewhat more constricted, less globose than *T. nodosum*. Young specimens of *T. newelli* may be distinguished by the concave, or channeled subsutural band, bordered by a row of pustules much stronger than those below.

I have before me, through the courtesy of Dr. Norman D. Newell, for whom the species is named, 27 specimens from the Vilas shale of Anderson County, Kansas. One of these is from a large quarry on the main highway two miles north of Garnett and 26, including the holotype, from the railroad quarry in the center of the SW. ¼, sec. 11, T. 20 S., R. 19 E.

The types of the species are in the collections of the Kansas Geological Survey.

TRACHYDOMA SAYREI Knight, n. sp.

Plate 45, figures 4*a–d*

Trachydomia wheeleri (Swallow)? Sayre, *1930*, Geol. Survey Kansas, Bull. 17, p. 151, pl. 18, figs. 4–4*a*, Westerville oölite, Pennsylvanian, Kansas City, Missouri.

Relatively small gastropods with the general characters of the genus. Within the genus the species is characterized by rather fine nodes or pustules commonly arranged in a quincunxial pattern. The umbilical region is notably flattened though at adult stages the height is about one to one. The subsutural smooth band is rather narrow and the uppermost pustules bordering it are not notably larger than those below. In a few

MEASUREMENTS OF *Trachydoma sayrei*

	A	B	C
Number of whorls	5½[a]	5½[a]	4½
Height	11.0 mm.	11.0 mm.	7.0 mm.
Width	10.5 mm.	10.5 mm.	6.0 mm.
Ratio of height to width	1.02	1.02	1.16
Ratio of height of body whorl to total	0.92	0.92	0.86
Pleural angle	103°	100°	90°

A. The holotype, seemingly a mature individual (Pl. 45, fig. 4*a*).
B. A paratype of about the same size (Pl. 45, fig. 4*b*).
C. A paratype, an ephebic but not old individual (Pl. 45, fig. 4*d*).

a Estimated on the assumption that 2½ apical whorls are missing.

specimens the pustules on the base are notably arranged in rather even rows.

T. sayrei is in some respects closest to *T. newelli* but differs in its smaller, more regularly arranged nodes, its relatively narrower and less channeled sutural band, its flatter base and its relatively lower spire. From *T. oweni* it is to be differentiated by the much finer nodes and relatively higher spire of that species.

The name is in honor of Dr. A. N. Sayre.

I have before me, through the courtesy of Dr. C. O. Dunbar of Yale, fourteen specimens including the holotype from the Westerville oolite at Kansas City, Missouri.

Holotype, Yale Peabody Museum, No. 14163.

TRACHYDOMA WHITEI Knight, n. sp.

Plate 46, figures 2*a–d*

Naticopsis wheeleri var. White, *1881*, U. S. Geog. Survey W. 100th Merid. **3**, Supp., Appendix, p. 33, pl. 4, figs. 6*a*, *b*., Pennsylvanian, near Taos, New Mexico.

Gastropods of medium size with the general character of the genus. Within the genus the species is characterized by its small but rather strong, quincunxially arranged and widely spaced pustules, its flat subsutural smooth band bordered by a shoulder bearing a single row of pustules somewhat larger than those below.

T. whitei is closest to *T. sayrei* but it is to be differentiated from that species by its flatter, wider subsutural band, its distinctly more prominent uppermost row of pustules and the

MEASUREMENTS OF *Trachydoma whitei*

	A	B
Number of whorls	5½[a]	5[a]
Height	15 mm.	11.25 mm.
Width	13.25 mm.	10.25 mm.
Ratio of height to width	1.13	1.10
Ratio of height of body whorl to total	0.88	0.89
Pleural angle	91°	90°

A. The holotype and largest specimen (Pl. 46, fig. 2*a–b*).
B. A paratype (Pl. 46, fig. 2*c–d*).

a Estimated on the assumption that 2 apical whorls are missing.

wider spacing and sharper definition of the pustules over the body of the whorl.

Through the courtesy of Dr. R. S. Bassler of the U. S. National Museum, I have been permitted to study the 55 specimens collected by the Wheeler survey from near Taos, New Mexico. The collection includes the specimen figured by White as *N. wheeleri*, variety, which is made the holotype of the new species. Dr. Newell, of Yale University and the Kansas Geological Survey, has loaned me a specimen collected from the base of the Vilas shale at a large quarry on the main highway two miles north of Garnett, Anderson County, Kansas. He has also loaned me three specimens from the Spring Hill member of the Plattsburg limestone that seem to belong to the same species. Two of these latter were collected about five miles southeast of Garnett, Kansas (SE. ¼, sec. 32, T. 21 S., R. 20 E.) and one from the Cement Plant quarry at Bonner Springs, Kansas.

Holotype and New Mexican paratypes, U. S. National Museum, No. 8932.

TRACHYDOMA OWENI Knight, n. sp.

Plate 46, figures 4*a–b*

Relatively small gastropods with the general characters of the genus. Within the genus the species is characterized by numerous very small but sharply defined nodes or pustules which have a tendency toward quincuxial arrangement though commonly rather irregular. The shell is notably high spired for the genus. The subsutural smooth band is well marked and rather flat.

In its relatively high spire *T. oweni* approaches *T. newelli* but its very fine pustules serve to distinguish it from that species, and, indeed, all other described species except *T. ortoni*. In *T. ortoni*, however, the pustules are so very faint as to be scarcely visible.

I have before me 25 specimens from a 2-foot ledge of algal limestone outcropping in the bank of Honey Creek (SW. ¼, SW. ¼, sec. 36, T. 43, R. 27) near Garland, Henry County, Missouri. This limestone is said to be about 100 feet below the top of the Cherokee shale (12, p. 375, Loc. 1268A$_2$). These were presented to me by Mr. John B. Owen, of Clinton, Missouri, in whose honor the species is named.

Holotype, Yale Peabody Museum, No. 14164.

MEASUREMENT OF *Trachydoma oweni*

	A	B
Number of whorls	5½[a]	5½[a]
Height	13.25 mm.	14.75 mm.
Width	11.0 mm.	12.5 mm.
Ratio of height to width	1.20	1.17
Ratio of height of body whorl to total	0.85	0.83
Pleural angle	92°	83°

A. The holotype (Pl. 46, fig. 4*b*).
B. A paratype (Pl. 46, fig. 4*a*).

a Estimated on the assumption that 2 apical whorls are missing.

TRACHYDOMA ORTONI (Whitfield)

Plate 46, figure 5

Naticopsis ortoni WHITFIELD, *1882*, Ann. New York Acad. Sci., **2**, p. 230, *1891*, op. cit., **5**, p. 605, pl. 16, figs. 12, 13, Geol. Survey Ohio, **7**, p. 489, pl. 12, figs. 12, 13, Pennsylvanian, Falls Township, Hocking County, Ohio.

Through the courtesy of Professor B. L. Clark, of the University of California, I have before me the holotype of the species described by Whitfield as *Naticopsis ortoni*. The specimen is wholly silicified and somewhat broken. It does not show well several important characters. Nevertheless it does show enough that one may say with some certainty that the species is referable to *Trachydoma* and the extremely faint development of the pustules is a sufficiently distinctive specific character to distinguish it at once from any other known species. The two uppermost rows of pustules are strongly enough developed to be seen without much difficulty but those over the general surface of the whorl are so very faint that it is most difficult to see them and almost impossible to photograph them. Nevertheless, faint though they be, the pustules are actually present.

EXPLANATION OF PLATE 46

FIGS. 1*a–f*—*Trachydoma moorei* Knight, n. sp. Page 390
All specimens from the Vilas shale of Anderson County, Kansas. All photographs ×2.
a–b, A large, probably gerontic individual, a paratype. The surface ornamentation is somewhat obscured through corrosion. *c–d*, A paratype, the ornamentation on the apertural side is obscured by corrosion. *e–f*, The holotype, *e* dorsal view, *f* same tipped back to show ornamentation on base. The anterior margin of the aperture is broken away.

2*a–f*—*Trachydoma whitei* Knight, n. sp. Page 386
All photographs ×2.
a–b, The holotype, the largest and best-preserved specimen in White's collection from near Taos, New Mexico. This is the specimen figured by White as *T. wheeleri* var. *c–d*, An early ephebic individual from the Vilas shale, Anderson County, Kansas.

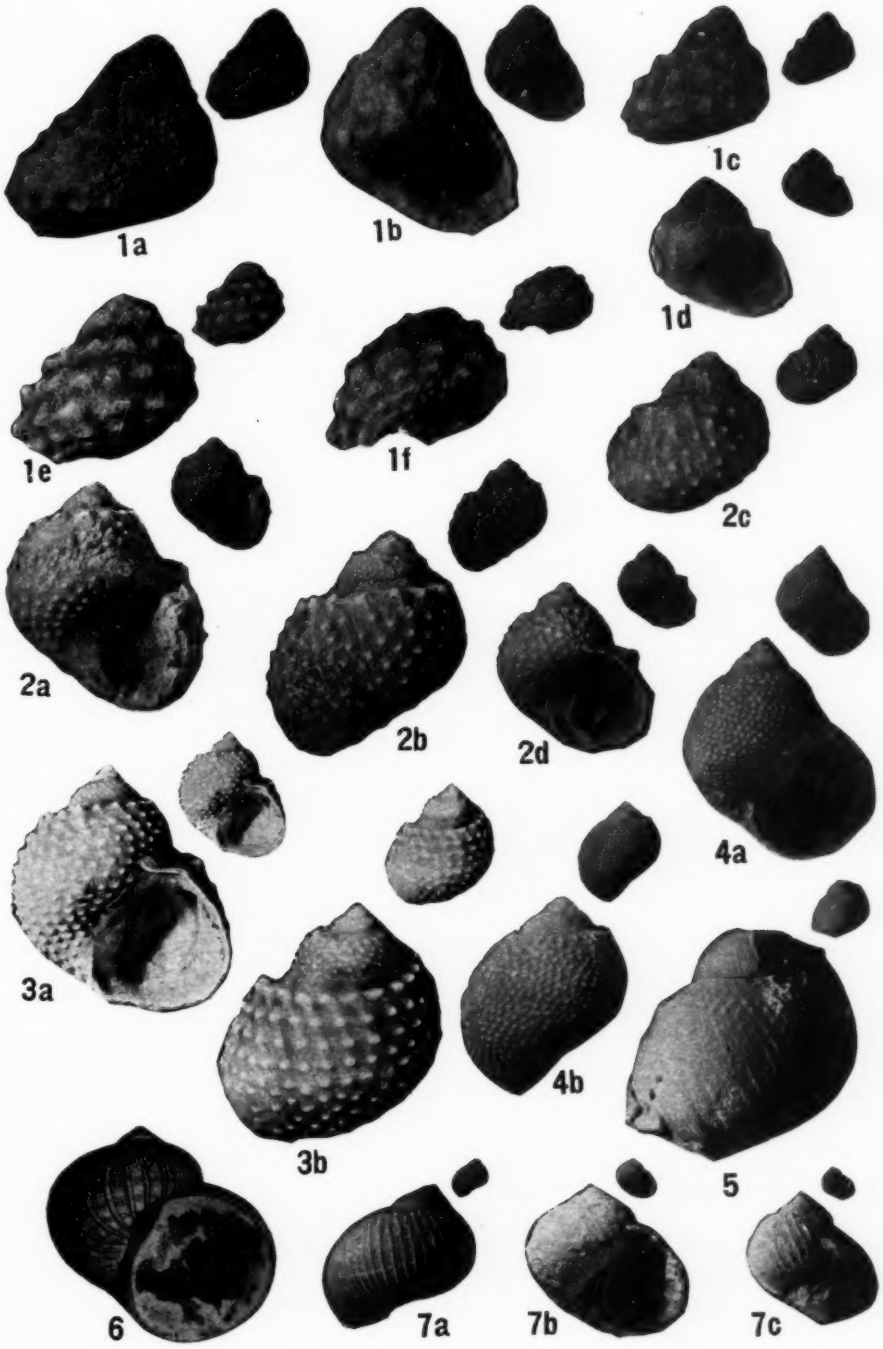
3*a–b*—*Trachydoma nodulosum* Worthen Page 389
A topotype specimen (×2). *b* is tilted slightly toward the reader. The anterior lip, as shown in *a*, is slightly broken away.

4*a–b*—*Trachydoma oweni* Knight, n. sp. Page 387
Photographs ×2. Both specimens from the Cherokee formation near Garland, Henry County, Missouri.
a, A paratype. *b*, The holotype. Both specimens seem to be of about the maximum size reached by this species.

5—*Trachydoma ortoni* Whitfield Page 388
Whitfield's holotype (×4). The two uppermost rows of pustules can be seen rather clearly, but those over the body of the whorl are so fine as to be scarcely visible.

6—*Natiria lirata* (Phillips) Page 364
This is a copy of one of de Koninck's figures (4, Pl. 3, fig. 17) of a plesiotype. *N. lirata* is the genotype of *Natiria* de Koninck. It should be noted that de Koninck's figures are notoriously inaccurate but no specimen of the species is available to me. This figure is introduced to show the general character of *Natiria*.

7*a–c*—*Natiria americana* (Girty) Page 391
All figures ×4. Three views of topotype specimens from near Garland, Henry County, Missouri. *b* shows important apertural and umbilical characters not given in the original figures or description.



Knight, Pennsylvanian gastropods

Whitfield's figures (op. cit.) of the species seem to show a much more perfectly preserved specimen than the one I have before me. Yet Whitfield states that the type of the species is at the University of California (16, p. 173), and Mr. Effinger of that institution writes me that the specimen sent me (Univ. Calif., Whitfield Coll. No. 1317) is the only specimen of the species in the collection. Furthermore the labels, which seem to be in Whitfield's own handwriting, give the specimen as the "type" of the species. Hence one is forced to conclude that Whitfield's figures are greatly restored or that the type specimen, of very fragile chert, was broken after the figures were made. In any case, if the specimen before me is not the holotype from which the original description and figures were drawn, it seems to be definitely of the same species and at worst must be a paratype or metatype.

TRACHYDOMA NODULOSUM Worthen

Plate 46, figures 3*a–b*

Trachydomia nodulosa WORTHEN, *1884*, Illinois State Museum Natural History, Bulletin, 2, p. 8, *1890*, Geol. Survey Illinois, 8, p. 146, pl. 23, figs. 11, 11*a*, Pennsylvanian, Peoria County, Illinois.

Gastropods of medium size with the general characters of the genus. Within the genus, the species is characterized by its small, but rather sharply defined pustules with a strong tendency to arrangement in revolving rows, and especially by the form of the anterior columellar portion of the aperture. The columellar lip, instead of swinging broadly to the right in its lower half, as in other known species, continues obliquely to the left and joins the anterior margin in a short, abrupt turn which simulates a notch, particularly if some of the anterior apertural margin is broken away.

T. nodulosum is perhaps closest in size and in the characters of its ornamentation to *T. whitei*, particularly when the tendency for the nodes to arrange themselves in revolving rows is not well expressed. It may be distinguished readily from *T. whitei* by its apertural characters since the lower part of the columellar lip in *T. whitei* swings broadly toward the right while that of *T. nodulosum* continues obliquely to the left and turns rather sharply to the right at its juncture with the anterior lip.

I have not been able to see the holotype of this species but there are in

MEASUREMENTS OF *Trachydoma nodulosum*

	A	B
Number of whorls	5½	5⅝[a]
Height	17.0 mm.	19.0 mm.
Width	14.0 mm.	17.5 mm.[b]
Ratio of height to width	1.21	1.09[b]
Ratio of height of body whorl to total	0.85	0.84
Pleural angle	91°	83°

A. A topoplesiotype (Pl. 46, fig. 3*a–b*).
B. A topoplesiotype, markedly gerontic. (Not figured.)

a Estimated on the assumption that 2 apical whorls are corroded.
b The shell seems somewhat distorted.

the Peabody Museum at Yale two specimens (No. 13893) presented to the late Prof. O. C. Marsh by Mr. G. H. Butterworth and by Prof. Marsh to the Museum. These two specimens were identified as *T. nodulosum*, they are labelled as having come from Worthen's locality, the Pennsylvanian of Peoria County, Illinois, and they agree in their characters with the details of Worthen's description and figures so well that there can be little doubt of the identification. Indeed there is every probability that they are authentic topotypes. The exact position of the type beds in the somewhat extended section of the Pennsylvanian in Peoria County is, unfortunately, not known.[4]

TRACHYDOMA MOOREI Knight, n. sp.
Plate 46, figures 1*a–f*

Gastropods of medium size, with the characters of the genus. Within the genus the species is characterized by coarse pustules arranged in revolving rows, and by its relatively narrow umbilical smooth band. The subtrochiform shape of the species also serves to characterize it. The pustules, of which there are from four to five rows on the whorl-face, and several rows of smaller ones on the base, are distinctly elongate in a revolving sense.

T. moorei is too distinctive in its characters to need comparison with any other species known in the American Pennsylvanian.

The unusual arrangement of the pustules on *T. moorei* coupled with equally unusual subtrochiform shape immediately raise the question of the propriety of referring the species to *Trachydoma*. Yet in all essential particulars, such as the parietal inductura, flattened in the plane of the aperture, the thickened and excavated columellar lip, the subsutural, somewhat collar-like, unornamented band, and in its pustulose ornamentation, it conforms to the characters of the genotype. While the species is certainly different from other rather compactly grouped species in the several respects enumerated, it hardly seems that the differences need to be given even subgeneric recognition.

I have before me, through the courtesy of Dr. Norman D. Newell,

[4] Though I reported this species from the Pawnee limestone in the St. Louis area (15, p. 45), it does not occur there. I used Worthen's name inadvertantly for *T. nodosa* (Meek and Worthen).

MEASUREMENTS OF *Trachydoma moorei*

	A	B	C
Number of whorls	6[a]	6[a]	5½[a]
Height	15.0 mm.	14.0 mm.[b]	9.75 mm.
Width	13.25 mm.	12.5 mm.	9.00 mm.
Ratio of height to width	1.13—	1.12	1.08
Ratio of height of body whorl to total	0.87	0.88	0.90
Pleural angle	74°	77°	78°

A. A paratype, the largest specimen (Pl. 46, fig. 1*a–b*).
B. The holotype (Pl. 46, fig. 1*e–f*).
C. A paratype (Pl. 46, fig. 1*c–d*).

a Estimated on the assumption that 2½ to 3 apical whorls are missing. Apices of all specimens badly corroded.
b Allowing about 2 mm. for break in lower lip.

nine specimens all from the Vilas shale of Anderson County, Kansas. One specimen, the largest, is from the railroad quarry in the center of the SW. ¼, sec. 11, T. 20 S, R. 19 E., and eight, including the holotype, are from a large quarry on the main highway two miles north of Garnett.

The types of the species are in the collections of the Kansas Geological Survey.

Genus NATIRIA de Koninck, 1881

NATIRIA AMERICANA (Girty)

Plate 46, figures 7*a–c*

Naticella americana Girty, *1915*, Missouri Bur. Geol. & Mines, (2), **13**, pp. 359, pl. 32, figs. 3–3*c*, 100± feet below top of Cherokee shale, Pennsylvanian near Garland, Henry County, Missouri.

Small, littoriniform gastropods with rather low spire and rapidly expanding body whorl; sutures shallow, but well defined, whorl profile and base strongly rounded, columella seemingly very minutely phaneromophalous; outer lip thin, slightly oblique; columellar lip and parietal inductura somewhat thickened in the plane of the aperture, the former distinctly channeled; ornamentation sharp, narrow, rather widely spread transverse costae which pass from the upper suture into the umbilical region; nucleus simple, smooth and dextral; color markings unknown.

This interesting species is reported in the literature only from its type horizon and locality cited above. My specimens are topotypes sent me by Mr. John B. Owen of Clinton, Missouri.

Cyrioplesiotype, Yale Peabody Museum, No. 14165.

MEASUREMENTS OF *Natiria americana*

	A	B	C
Number of whorls	5	5	4½
Height	5 mm.	5.02 mm.	4.4 mm.
Width	5 mm.	5.04 mm.	4.4 mm.
Ratio of height to width	1.00	.099	1.00
Ratio of height of body whorl to total	0.84	0.90	0.89
Pleural angle	103°	110°	98°
Number of costae, body whorl	33	30	27

A. A plesiotype, apparently mature (Pl. 46, fig. 7*a*).
B. The cyrioplesiotype, apparently mature (Pl. 46, fig. 7*b*).
C. A plesiotype, somewhat smaller (Pl. 46, fig. 7*c*).

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ARENACEOUS FORAMINIFERA FROM THE LOWER PALEOZOIC ROCKS OF OKLAHOMA

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ABSTRACT

One new genus and ten new species of arenaceous foraminifera have been discovered in samples of Viola, Chimney Hill, Haragan, and Woodford formations of the Arbuckle Mountain region. Nine of the species belong to the more primitive families, while a new genus, *Kerionammina*, represented by one new species, belongs to family Neusinidae, which has formerly been described only from recent material.

A discussion of the geologic range of arenaceous foraminifera is included.

The material described in this paper is a portion of that collected during the summer of 1932 in the Arbuckle Mountain region of southern Oklahoma. This work was made possible by a grant-in-aid from the National Research Council in cooperation with funds from Texas Christian University; and was carried out for the purpose of determining the character and geologic range of arenaceous foraminifera in the Early Paleozoic.

The foraminifera here described came from samples of limestone collected at approximately 10-foot intervals from the Viola, Chimney Hill, Haragan, and Woodford formations. Decker[1] correlates the Viola with the Mayville-Eden, which is Upper Ordovician; the Chimney Hill with the Brassfield, which is Middle Silurian; the Haragan with the New Scotland beds of the Helderberg, which is Lower Devonian; and the Woodford with the Kinderhook, which is Lower Mississippian. Samples examined from the Henry House formation, which is Niagaran in age, were found to contain species identical with those in the Chimney Hill formation.

Since the discovery by the writer, in 1930, of unquestionable foraminifera of pre-Carboniferous age in the Arbuckle Mountain region almost identical faunas have been found in other regions. In the Brassfield of southeastern Missouri and near Joliet Illinois, Croneis, Dunn, and Hunter[2] have found species identical with those in the Chimney Hill formation. In the Baltic Silurian Eisenack[3] has identified *Psammosphaera cave* Moreman, and also has described two new genera and four new species of are-

[1] Decker, C. E., *Guide Book, Fifth Annual Field Conf., Kansas Geol. Soc.*, p. 17, 1931.

[2] Croneis, Dunn, and Hunter, Pre-Carboniferous foraminifera: *Science*, vol. 75, no. 1935, p. 138, 1932.

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naceous foraminifera from the same material. From the evidence now at hand it appears that at least some of the formations contain characteristic foraminifera. So far, not a single species from the Viola formation has been found in the Chimney Hill, and the few specimens which have been observed from the Woodford formation are different from those in either the Viola or Chimney Hill. Some of the Chimney Hill species, however, extend up through the Henry House and Haragan formations; but the Haragan contains some species which have not been observed in the Chimney Hill. Species of *Raibosammina*, a genus described from the lower Viola, have been observed in a residue of lower Trenton from the Glass Mountains southwest of Marathon, Texas. It is possible that part of the Viola is of Trenton age.

Of the ten species here described, nine belong to the more primitive families of foraminifera, including Astrorhizidae, Rhizamminidae, Saccamminidae, Hyperamminidae, and Ammodiscidae, while one species representing a new genus, *Kerionammina*, belongs to the more complex family, Neusinidae, known previously only from recent material.

The illustrations used to make the plate were drawn by Mrs. W. L. Moreman.

DESCRIPTION OF LOCALITIES

Locality 1. Viola formation, about 300 feet above the base and 25 feet east of U. S. Highway 77, 3 miles north of Springer, Oklahoma.

Locality 2. Chimney Hill formation, on east side of U. S. Highway 77, 2.8 miles north of Springer, Oklahoma.

Locality 3. Chimney Hill formation, near Burrow-Bromide road, north of Bromide, Oklahoma.

Locality 4. Haragan formation, on east side of U. S. Highway 77, 2.75 miles north of Springer, Oklahoma.

Locality 5. Woodford formation, basal member, about 50 feet east of U. S. Highway 77, 2.65 miles north of Springer, Oklahoma.

DESCRIPTION OF SPECIES

Order FORAMINIFERA

Family ASTRORHIZIDAE

Genus RHABDAMMINA M. Sars, 1869

RHABDAMMINA TRIFURCATA Moreman, n. sp.

Plate 47, figure 12

Test free, medium size, consisting of a small central chamber with three radiating arms; wall thick, composed of a mixture of very small and relatively large sand grains held together with a small amount of cement, the wall of the central chamber consisting of small grains exclusively, exterior rough; minute aperture at the end of each arm.

Measurement from tip of one arm to base of triangle formed by the other two arms: 1.08 mm.

This species differs from *Rhabdammina abyssorum* M. Sars, because of its smaller size, relatively larger sand grains which are poorly sorted, and in having smaller apertures, in some cases practically indistinct. The central chamber is relatively smaller

and the passages through the arms are of a very small diameter.

Holotype, from the Viola formation. Loc. 1.

Family RHIZAMMINIDAE

Genus MARSIPELLA Norman, 1878

MARSIPELLA AGGREGATA
Moreman, n. sp.
Plate 47, figures 11, 14

Test free, small, elongate, consisting of one long tubular chamber; wall thick, composed of relatively large angular sand grains held together by a very little cement, exterior rough and rugged, interior wall smooth; rounded aperture at each end of the tube, or sometimes closed at one end by a loosely aggregated knob of sand grains.

Length of figured specimens: 0.87 and 1.18 mm.

This species differs from the genoholotype, *Marsipella elongata* Norman, in not having sponge spicules incorporated in the wall of the test, but resembles it very closely in all other features.

Cotype, from the Viola formation. Loc. 1.

Family SACCAMMINIDAE

Subfamily SACCAMMININAE

Genus SACCAMMINA M. Sars, 1869

SACCAMMINA BIOSCULATA
Moreman, n. sp.
Plate 47, figure 6

Test free, of medium size, that part of the chamber below the neck subspherical, neck about two-ninths the length of the entire test; wall thin, composed of medium sand grains put together with a small amount of cement, exterior rough; the short, fat neck is divided about half way down into two smaller necks which protrude almost at right angles to each other, each bearing an aperture with irregular margins.

Length of figured specimen: 0.59 mm.

Saccammina biosculata differs from other species of the genus in having the neck divided shortly above the base, thus forming two apertures.

Holotype, from the Chimney Hill formation. Loc. 2.

Genus LAGENAMMINA Rhumbler, 1911

LAGENAMMINA CUCURBITA
Moreman, n. sp.
Plate 47, figure 5

Test free, medium size, bottle-shaped, that part of the chamber below the neck almost perfectly spherical, neck about two-fifths the length of the entire test; wall thin, composed of medium sand grains, small amount of cement, surface rough, aperture circular at the end of an elongate neck.

Length of figured specimen: 0.8 mm.

Lagenammina cucurbita is usually about twice the size of *Lagenammina sphaerica* Moreman and has a relatively shorter neck.

Holotype, from the Chimney Hill formation. Loc. 2.

Subfamily WEBBINELLINAE

Genus WEBBINELLA Rhumbler, 1903

WEBBINELLA THOLUS
Moreman, n. sp.
Plate 47, figures 8, 10

Test attached, small to medium

size, hemispherical; one chamber; wall thin, composed of medium sand grains with a medium amount of cement, several large sand grains attached or perhaps partially incorporated in the wall, exterior rough; no definite aperture.

Diameter of figured specimen: 0.45 mm.

Webbinella tholus differs from *Webbinella hemisphaerica* Jones, Parker and H. B. Brady in showing a poor assortment of sand grains in building the test, using a smaller amount of cement, and in not having a very distinct flattened border around the base.

Holotype, from the Viola formation. Loc. 1.

WEBBINELLA QUADRIPARTITA
Moreman, n. sp.
Plate 47, figures 4, 7

Test attached, medium size, composed of four hemispherical chambers of equal size and shape arranged in the same plane to form a rude diamond; wall thin, composed of medium sand grains held together with a small amount of cement, exterior rough; aperture not apparent.

Length of figured specimen: 0.95 mm.

The chambers of *Webbinella quadripartita* do not seem to communicate with each other but each is firmly cemented, at the base, to the adjoining ones.

Holotype, from the Haragan formation. Loc. 4.

Family HYPERAMMINIDAE
Subfamily HYPERAMMININAE

Genus HYPERAMMINA H. B. Brady, 1878

HYPERAMMINA HASTULA
Moreman, n. sp.
Plate 47, figure 2

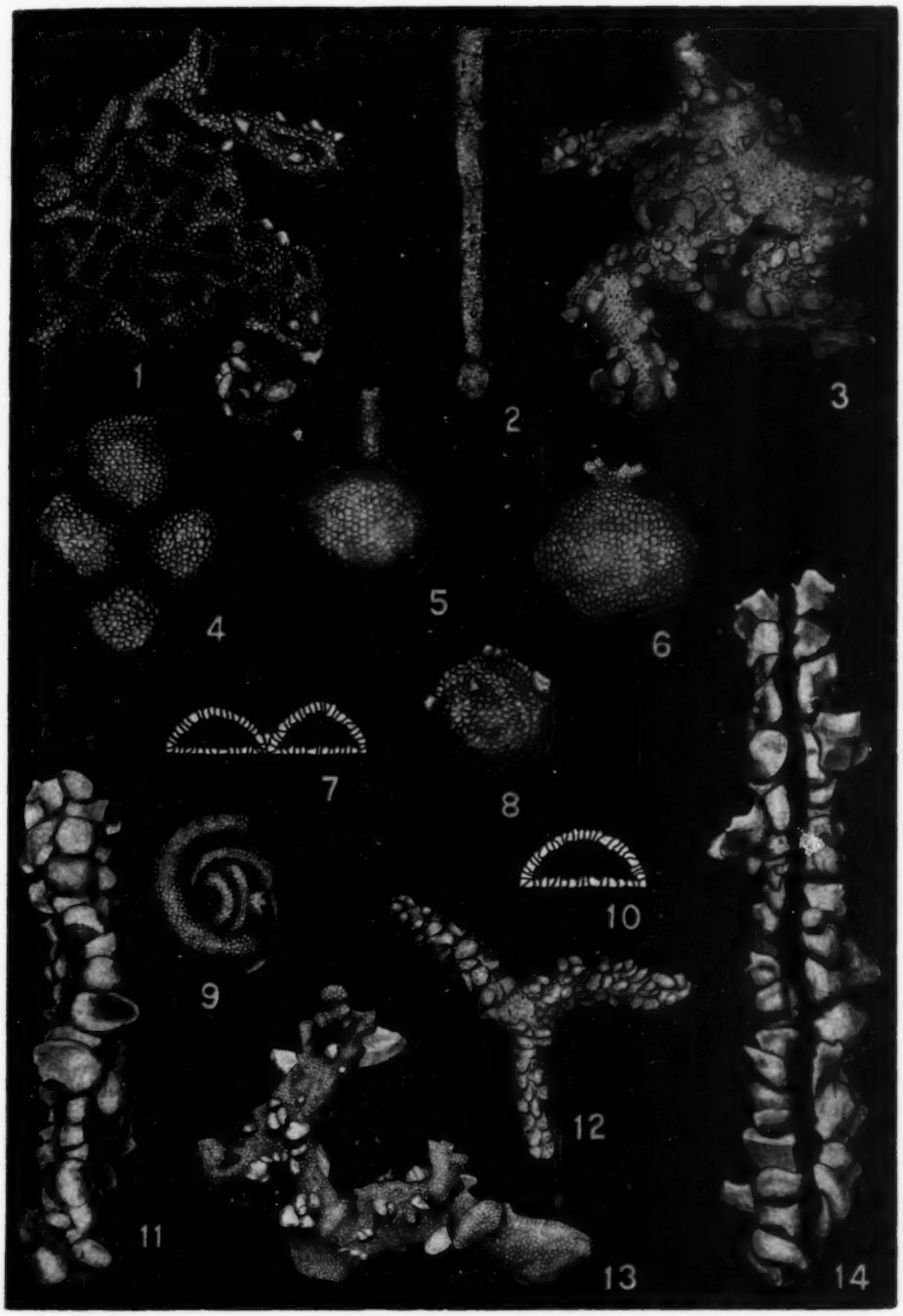
Test free, elongate, medium size, consisting of a small spherical proloculum and a long tubular second chamber; wall thin, composed of small to medium sand grains set together with a small amount of cement, exterior rough; large aperture formed by the open end of the tube.

Length of figured specimen: 1.3 mm.

The proloculum of *Hyperammina hastula* is smaller in proportion to the length of the tube and more distinctly formed than that of *Hyperammina elongata* H. B. Brady. The wall of the test is thinner, being composed of rather fine sand grains, and the canal of the second chamber is relatively greater in diameter.

DESCRIPTION OF PLATE 47

FIGS. 1, 3—*Kerionammina favus*, n. gen. et. n. sp. ×41.
2—*Hyperammina hastula*, n. sp. ×40.
4, 7—*Webbinella quadripartita*, n. sp. ×37.
5—*Lagenammina cucurbita*, n. sp. ×34.
6—*Saccammina biosculata*, n. sp. ×39.
8, 10—*Webbinella tholus*, n. sp. ×39.
9—*Glomospira biplana*, n. sp. ×78.5.
11, 14—*Marsipella aggregata*, n. sp. ×81.5.
12—*Rhabdammina trifurcata*, n. sp. ×39.
13—*Saccorhiza flexiliramosa*, n. sp. ×34.



Moreman, Lower Paleozoic foraminifera

Holotype, from the Chimney Hill formation. Loc. 3.

Subfamily DENDROPHRYINAE

Genus SACCORHIZA Eimer and Fickert, 1899

SACCORHIZA FLEXILIRAMOSA
Moreman, n. sp.
Plate 47, figure 13

Test free, elongate, tubular, slightly twisted and irregularly branched; consists of a small, slightly bulbous proloculum and branching second chamber; wall thick, composed mainly of fine sand grains with much cement, but having large sand grains incorporated and attached at intervals, exterior rough; apertures, one at each free end of a branch.

Length of figured specimen: 1.5 mm.

Saccorhiza flexiliramosa differs from *Saccorhiza ramosa* H. B. Brady in showing a poor assortment of sand grains in making the test, and in not including sponge spicules in the test.

Holotype, from the Woodford formation. Loc. 5.

Family AMMODISCIDAE
Subfamily AMMODISCINAE

Genus GLOMOSPIRA Rzehak, 1888

GLOMOSPIRA BIPLANA
Moreman, n. sp.
Plate 47, figure 9

Test free, small size, consisting of a proloculum and tubular second chamber coiling in two planes, the later portion consisting of one and one-half volutions coiled at right angles to the earlier portion; wall thin, composed of very fine sand grains held together with a moderate amount of cement, exterior slightly irregular, but smooth; large aperture at end of coil.

Diameter of figured specimen: 0.3 mm.

The diameter of the second chamber of *Glomospira biplana* is greater in proportion to the size of the test than that of *Glomospira gordialis* (Jones and Parker), and it is slightly shorter, thus making fewer coils.

Family NEUSINIDAE

Genus KERIONAMMINA, Moreman, n. gen.

Test medium size, attached, early portion obscure, later portion spreading in a flattened irregular manner; wall arenaceous; interior labyrinthic but tending to become divided into somewhat regularly arranged chamberlets; apertures at the end of tubular portions which grow parallel with the periphery or branch out from it.

Genotype *Kerionammina favus*, n. sp.

KERIONAMMINA FAVUS
Moreman, n. sp.
Plate 47, figures 1, 3

Test attached, medium size, early portion obscure, later portion spreading in a flattened irregular manner; wall thick, composed of medium to large sand grains held together with a moderate amount of cement, exterior rough, interior divided into irregular chamberlets with relatively smooth partitions; apertures large, situated at the end of tubular portions which grow around the periphery or branch out from it.

Height of figured specimen: 1.33 mm.

Holotype, from the Viola formation. Loc. 1.

JOURNAL OF PALEONTOLOGY, VOL. 7, NO. 4, PP. 398–405, PL. 48, DECEMBER, 1933

SOME MORRISON OSTRACODA

ROBERT ROTH

ABSTRACT

One new genus, *Pseudocypridina*, and seven new species of ostracodes from the Morrison formation of the Black Hills, South Dakota, are described. Comparison with Texas Comanchean fossils indicates that the Morrison probably is not of Lower Cretaceous age.

Study of the Morrison formation leads at once to the question whether it is Lower Cretaceous or Jurassic in age. The Morrison may be traced as a lithologic unit over an enormous area and is separated by an unconformity from the overlying Cretaceous and underlying Jurassic or pre-Jurassic rocks. It is not a marine formation but seems to have been deposited partly under eolian conditions and partly in a fresh- or brackish-water environment. Many bones of large saurians have been found and study of them has divided the vertebrate paleontologists into two groups. The first group finds evidence of Jurassic age, while the other believes that there is just as good evidence of Lower Cretaceous age. So far, the invertebrate paleontologists have been more or less interested spectators. The invertebrate fossils consist mostly of fresh-water species such as *Unio felchi* White, *Unio iridoides* White, a species of *Limneae* and some other forms. A *Chara*-like alga occurs also.

When the author obtained a splendid collection of ostracodes from the Morrison in the Black Hills of South Dakota, he decided to make some comparisons with ostracodes from the lower Comanchean of Texas. This he has done and the results are presented in the following pages.

Investigation indicates that there is no equivalent of the Morrison in the Comanchean, as far as the author is aware. There are perhaps three reasons for this: (1) the comparisons are between what is probably a brackish-water environment on the one hand and a typical marine environment on the other; (2) lack of fossiliferous material in the Comanchean adjacent to the Morrison; and (3), the paucity of reliable literature on the subject. The Morrison faunule shows a great variety of forms which, is not usually the case in fresh-water deposits of the present time, and because of this the writer believes the deposits of the Morrison may not be strictly fresh-water. Also, in studying the ostracodes it was noted that in many cases the carapace was filled with what appears to be kerogen. This was tested by drying a screen

sample for forty-eight hours at 220° F. and then igniting, as a result it was found that the ignition loss was 27.78 percent by weight. This loss was probably all kerogen or an allied substance. This evidence adds to probability that a brackish-water environment existed, and if this is true a better basis for comparison with the marine Comanchean of Texas is presented. There is surprisingly little similarity, however, in the fossils from the two areas. Taking the faunule as a whole, there is more simplicity in general form in the Morrison ostracodes than in the Comanchean. In the latter there is a greater tendency towards the bizarre, which usually means greater age for the individual, though in this case the difference may be due to nonmarine environment of the Morrison. Taking everything into consideration, the writer is of the opinion that the Morrison probably is not contemporaneous with the Comanchean of Texas. Following is a stratigraphic section of the Morrison along with the field relationships at the locality from which the material was collected.

GENERALIZED SECTION OF THE MORRISON FORMATION

Section 28, Township 4 North, Range 6 East

Lawrence County, South Dakota

	Thickness Feet
Lower Cretaceous	
Lakota formation	
Buff massive sandstone	31
Lower Cretaceous (?)	
Unconformity	
Morrison formation	
Shale, gray to blue, silicified wood	20
Sand, soft, white	12
Talus (shale)	60
Sandstone, contains two hard ledges	20
Shale, containing thin brown to pink limestone layers which are practically made up of one species of ostracodes, while the shale contains other ostracodes, also fish teeth	20
Shale containing silicified wood and *Barosaurus*, *Morosaurus*, and other large dinosaurs; nodular limy layers near base	80
Jurassic	
Unconformity	
Unkpapa sandstone	
Greenish-gray fine-grained sandstone	61
Unconformity	
Sundance formation	
Green to gray sandy shale	37
Greenish thin-bedded sandstone	61
Green to gray shale with thin sandy gray limestone layers, pink to red near base	241
Unconformity	

DESCRIPTION OF SPECIES

Family KLOEDENELLIDAE Ulrich and Bassler, 1923

Genus JONESINA Ulrich and Bassler, 1909

JONESINA MINNEKAHTENSIS Roth, n. sp.

Plate 48, figures 1*a–g*

General outline in side view subrectangular, dorsal view subcordate, maximum length midway between dorsal and ventral margins. Maximum height just posterior of the anterior cardinal angle. Maximum breadth in the plane of maximum height. Anterior end the most tumid,

the posterior end containing the sulci and most acuminate, thus distinguishing the anterior from the posterior extremity. Valvular overlap not very apparent; right valve, however, having a faint flange along the free margin and hinge-line which fits into a groove similarly placed on the left valve. The left valve has a faint tooth on the anterior cardinal angle which fits into a similarly placed socket on the right valve. Dorsal margin not clearly defined as it grades into the anterior and posterior extremities. It occupies about one-half of the maximum length of the carapace. Hingement rather well developed, consisting of a groove and flange and the above described dentition. Anterior cardinal angle breaks sharply into anterior extremity while the posterior cardinal angle is not very distinct. Anterior half of hinge-line depressed and paralleled by striations on both valves along the depression. Posterior half of hinge-line consists of a sharp ridge above the sulci. Ventral margin sinuate but over all slightly convex. Bifurcating riblets parallel the ventral margin. The whole margin is slightly depressed due to tumidity of anterior part of carapace. Anterior extremity broadly arcuate in side view but the free margin is depressed. Posterior extremity irregularly arcuate and consists of two faint ridges paralleling the free margin. The whole is quite thin. Surface ornaments consist of a meshwork of polygonal pits which become elongated into parallel riblets along the ventral margin and the depression along the hinge-line. There is no central pit or muscle scar. Two sulci occur just below posterior half of hinge-line. Anterior sulcus, which is the more pronounced, extends downward from the hinge-line to the plane of maximum length. It is strongly inclined towards the posterior at its ventral termination. The posterior sulcus is much fainter, being about one-half as long as the anterior sulcus. It occurs just under the posterior cardinal angle. The anterior dorsal portion of the carapace contains a few irregularly placed minute tubercles; there is usually one on each valve just under the anterior cardinal angle.

Dimensions.—Maximum length, 1 mm.; maximum height, 0.56 mm.; maximum breadth, 0.72 mm.

Generic and specific relationships.—The relationships of *Jonesina minnekahtensis* and *J. pahasapensis* will be dealt with together. Several points in connection with these two species have kept the author "in hot water" for some time. This is especially so with *J. minnekahtensis* (hence the specific name, for Minnekahta, in Sioux, means hot water). The difficulty is that these species, which occur in great numbers, may be male and female. If this is so, and if they are truly Jonesinas, then a reversal in orienting them is necessary. The most tumid end, here called anterior, will be termed the posterior. The designation of valvular overlap will be reversed and the "backward" swing of the sulci can no longer be used as indicating the posterior but would indicate the anterior instead. This character would not only affect

the Jonesinas as a group but would affect many other genera of ostracodes as well. Since absolute proof is wanting, the writer believes that for the present no change should be made. There are certain ornamental characteristics on the ventral side in the two Morrison species which suggest that *Cythere* is probably a development from this stock. As a whole, the above described species will be readily distinguishable from all other forms.

Holotype.—U. S. National Museum, No. 74,467.

Horizon and locality.—Very abundant in the lower shales of the Morrison formation, sec. 28, T. 4 N., R. 6 E., Lawrence County, South Dakota.

JONESINA PAHASAPENSIS Roth, n. sp.
Plate 48, figures 2*a–g*

General outline subrectangular, otherwise this form is exactly similar to *Jonesina minnekahtensis* except that the great anterior tumidity is absent. It is still, however, the thickest portion of the carapace. Ventral margin not depressed, as in the previous case, but slightly convex and flat; that is, the sides of the carapace do not slope into the ventral margin but come down rather straight and then turn abruptly into the ventral margin, thus giving the appearance of a sort of flange. The posterior extremity is not nearly as pinched as in the case of *J. minnekahtensis*. Surface ornaments are the same in both cases, but the tubercles in the anterior portion are very pronounced though without geometric distribution.

Dimensions.—Maximum length, 0.88 mm.; maximum height, 0.52 mm.; maximum breadth, 0.44 mm.

Holotype.—U. S. National Museum, No. 74,468

Horizon and locality.—Morrison formation, sec. 28, T. 4 N., R. 6 E., Lawrence County, South Dakota.

Family BAIRDIIDAE Ulrich and Bassler, 1923

Genus BYTHOCYPRIS Brady, 1880

Subgenus BAIRDIOCYPRIS Kegel, 1931

BAIRDIOCYPRIS MORRISONENSIS Roth, n. sp.
Plate 48, figures 4*a–c*

General outline subreniform. Maximum length approximately two-thirds of the distance from dorsal margin to the ventral margin. Maximum height slightly posterior to central portion of the carapace. Maximum breadth approximately in a line at right angles to the junction of the maximum length and maximum height. Anterior end slightly thinner and more acuminate, the posterior end blunter and more sharply pointed at the junction of the posterior extremity with the ventral margin. Valvular overlap not very prominent except over the hinge-line and along the middle portion of the ventral margin. Dorsal margin broadly arcuate. The left valve extends well above the right valve but not markedly overlapping it. Hinge-line simple and straight, extending the length of the umbo of the left valve and slightly inclined toward the anterior. Ventral margin concave and extending practically the maximum length of the valve. It is gently arcuate at the anterior extremity but much more

sharply arcuate at the posterior. The left valve slightly overlaps the right along the middle portion of the ventral margin. Anterior extremity rather uniformly arcuate and with practically no valvular overlaps. Posterior extremity quite blunt, as the line extending from the posterior termination of the hinge-line to the ventral margin is only very slightly arcuate. Surface ornaments are wanting except in very well-preserved forms, in which case the carapace shows a great number of extremely minute pits.

Dimensions.—Maximum length, 2.9 mm.; maximum height, 1.9 mm.; maximum breadth, 1.3 mm.

Generic and specific relationships.—The relationships of this species are very distinct, as it clearly falls into the subgenus *Bairdiocypris*. Specifically there are no close relationships, for no other form is known to the writer to have the pronounced umbonal character of the left valve.

Holotype.—U. S. National Museum, No. 74,469.

Horizon and locality.—Occurs only in the thin limestone shells of the lower Morrison to the exclusion of all other forms. Sec. 28, T. 4 N., R. 6 E., Lawrence County, South Dakota.

BAIRDIOCYPRIS TRAPEZOIDALIS Roth, n. sp.
Plate 48, figures 6*a–d*

General outline subtrapezoidal. Maximum length midway between the dorsal and ventral margins. Maximum height may be taken at either the anterior or posterior cardinal angle. Maximum breadth at the middle of the carapace. Anterior extremity may be determined by the most obtuse cardinal angle and by the right valve very slightly overlapping in this region. Valvular overlap very distinct along the ventral margin and also along the hinge-line, elsewhere not so apparent. Dorsal margin practically straight with a slight inclination toward the posterior. The left valve extends well above the right valve along this margin. Hingement is a straight line and appears to be slightly inclined towards the posterior. It is simple in charac-

DESCRIPTION OF PLATE 48

FIGS. 1*a–g*—*Jonesina minnekahtensis* Roth, n. sp. *a*, Dorsal aspect, ×25. *b*, Ventral aspect, ×25. *c*, Anterior extremity, ×25. *d*, Posterior extremity, ×25. *e*, Dorsal aspect, ×25. *f*, Dorsal aspect, ×25. *g*, Left valve, ×25.

2*a–g*—*Jonesina pahasapensis* Roth, n. sp. *a*, Dorsal aspect, ×25. *b*, Ventral aspect, ×25. *c*, Dorsal aspect, ×25. *d*, Left valve, ×25. *e*, Left valve, ×25. *f*, Anterior extremity, ×25. *g*, Posterior extremity, ×25.

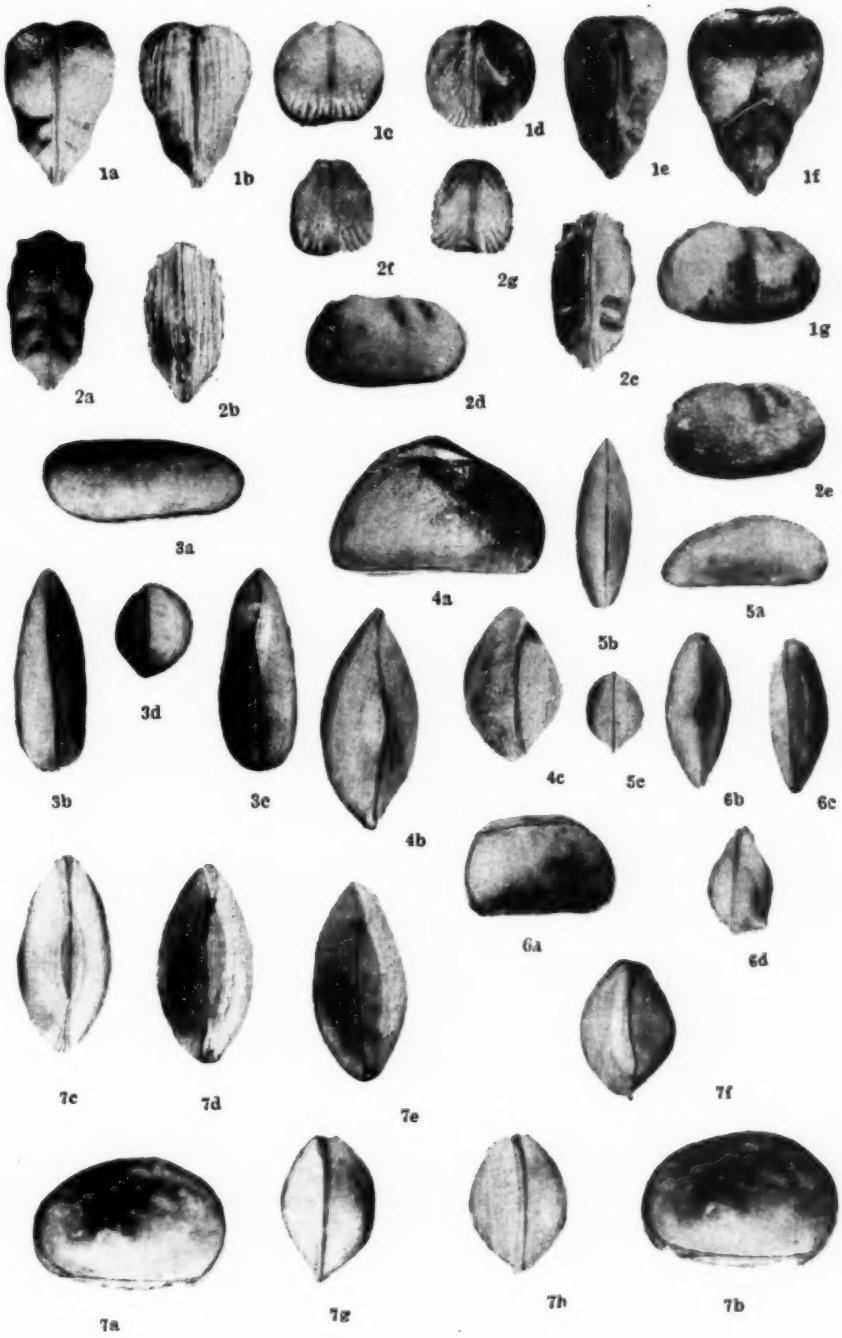
3*a–d*—*Paracypris simplus* Roth, n. sp. *a*, Right valve, ×25. *b*, Dorsal aspect, ×25. *c*, Ventral aspect, ×25. *d*, Anterior aspect, ×25.

4*a–c*—*Bairdiocypris morrisonensis* Roth, n. sp. *a*, Right valve, ×10. *b*, Dorsal aspect, ×10. *c*, Posterior aspect, ×10.

5*a–c*—*Paracypris acuminatus* Roth, n. sp. *a*, Right valve, ×25. *b*, Dorsal aspect, ×25. *c*, Anterior aspect, ×25.

6*a–d*—*Bairdiocypris trapezoidalis* Roth, n. sp. *a*, Right valve, ×25. *b*, Dorsal aspect, ×25. *c*, Ventral aspect, ×25. *d*, Anterior aspect, ×25.

7*a–h*—*Pseudocypridina piedmonti* Roth, n. gen., n. sp. *a*, Right valve, ×25. *b*, Right valve, ×25. *c*, Dorsal aspect, ×25. *d*, Ventral aspect, ×25. *e*, Ventral aspect, ×25. *f*, Posterior extremity, ×25. *g*, Anterior extremity, ×45. *h*, Anterior extremity, ×25.



Roth, Morrison ostracodes

ter, terminating in two obtuse angles, the anterior angle being the greater. Ventral margin concave, and the overlapping left valve most prominent in the central part and fades both anteriorly and posteriorly. Anterior extremity broadly arcuate; the overlap is faint. Posterior extremity gently arcuate except where it joins the ventral margin. There it is quite acute. Surface ornaments consist of a straight ridge or semi-false keel paralleling the middle part of the ventral margin and very close to it. The carapace is practically smooth except for some very faint pits of minute size. There are no other ornaments.

Dimensions.—Maximum length, 0.84 mm.; maximum height, 0.56 mm.; maximum breadth, 0.36 mm.

Generic and specific relationships.—Not as clear in this form as they are in *Bairdiocypris morrisonensis.* The trapezoidal outline is distinct. Also, the shelf or ridge paralleling the ventral margin on the left valve is unique in this form.

Holotype.—U. S. National Museum, No. 74,470.

Horizon and Locality.—Occurs in the lower shales of the Morrison and is quite rare. Sec. 28, T. 4 N., R. 6 E., Lawrence County, South Dakota.

Family CYPRIDAE Zenker

Genus PARACYPRIS Sars

PARACYPRIS SIMPLUS Roth, n. sp.

Plate 48, figures 3*a–d*

General outline subellipsoidal, the whole being slightly arcuate. Maximum length midway between dorsal and ventral margin. Maximum height approximately two-thirds of the distance from the anterior to the posterior extremity. Maximum breadth slightly anterior to plane of maximum height and in plane of maximum length. Anterior end identified as the thinner. Valvular overlap fairly strong. The right valve plainly overlapped by the left valve all along the free margin. Dorsal margin not clearly separated from the anterior and posterior extremities, as it grades gently into the anterior extremity and acutely into the posterior extremity. The whole is gently arcuate. Hingement is very primitive and consists of a straight line, neither valve overlapping. The anterior cardinal angle is more obtuse. The hinge-line as a whole is parallel to the ventral margin. Ventral margin gently concave. This concavity is slightly exaggerated just before joining the anterior extremity, and is the region where maximum overlap of the right valve by the left valve occurs. Anterior extremity gently ovate with overlap by left valve increasing toward ventral margin. Posterior extremity bluntly ovate with overlap of right valve fading out towards hinge-line. All surface ornaments are wanting.

Dimensions.—Maximum length, 1.08 mm.; maximum height, 0.48 mm.; maximum breadth, 0.4 mm.

Generic and specific relationships.—The relationship of this species is complicated in that superficially it strongly resembles *Cytherella.* Upon examination, however, it is found that a hinge-line exists and if the thickest portion of the carapace is chosen as posterior, then the left valve over-

laps the right valve. This is the reverse of *Cytherella*. Also, *Cytherella* is not described as having a pronounced hinge-line. In general outline there is a close relationship to *Macrocypris* and *Pontocypris*, but the overlap is different. Just what the relationship to *Pseudocythere simplex* is the writer cannot at present determine. *Acratia* has both extremities sharply pointed. *Paracypris* differs from *Bairdianella* only in general outline, the overlap being much the same.

Holotype.—U. S. National Museum, No. 74,471.

Horizon and locality.—This form occurs in the shales of the lower Morrison and is quite rare. Sec. 28, T. 4 N., R. 6 E., Lawrence County, South Dakota.

PARACYPRIS ACUMINATUS Roth, n. sp.

Plate 48, figures 5*a–c*

General outline subreniform, very compressed, and sharply acuminate posteriorly. Maximum length close to ventral margin. Maximum height two-thirds of the way from the posterior to the anterior extremity. Maximum breadth slightly anterior to central part of carapace. Posterior end sharply acuminate, the anterior end broader, ovate and thick. Valvular overlap practically wanting, left valve slightly overlapping right valve along central part of ventral margin. Right valve extends slightly above left valve along the hinge-line. Dorsal margin irregularly arcuate, curvature increasing markedly anterior to maximum height. Hingement very primitive; hinge-line straight and extending for about one-half the distance of the maximum length. It is strongly inclined towards the posterior. Ventral margin gently concave. Anterior extremity uniformly ovate; posterior extremity acuminate toward ventral margin. Surface ornaments are wanting.

Dimensions.—Maximum length, 0.92 mm.; maximum height, 0.44 mm.; maximum breadth, 0.32 mm.

Generic and specific relationships.—This species is very closely related to *Macrocypris* but, if the arcuate extremity is chosen as the posterior, the overlap is the reverse of that in *Macrocypris*. It may be distinguished from *Paracypris weatherfordensis* Vanderpool by the greater size and difference in amount of overlap of the Morrison form.

Holotype.—U. S. National Museum, No. 74,472.

Horizon and locality.—Found only in the lower shales of the Morrison, and is quite rare. Sec. 28, T. 4 N., R. 6 E., Lawrence County, South Dakota.

Family CYPRIDINIDAE Baird, 1850

Genus PSEUDOCYPRIDINA Roth, n. gen.

PSEUDOCYPRIDINA PIEDMONTI Roth, n. sp.

Plate 48, figures 7*a–h*

General outline sub-hemicircular. Maximum length midway between the anterior termination of the hinge-line and the ventral margin. Maximum height approximately one-third of the distance from the anterior extremity to the posterior. Maximum breadth in the plane of maximum length and slightly toward the posterior in the central part of the carapace. The anterior extremity may be defined as the portion containing the

diagnostic beak. The hinge-line markedly inclined toward the posterior. Valvular overlap not prominent. The left valve is slightly larger along the ventral margin, while the right valve extends slightly above the left valve along the hinge-line, yet bends downward to fit under the left valve. Along the anterior extremity the right valve fits slightly under and is overlapped by the left valve. This continues to the beak. Dorsal margin broadly arcuate except along the hinge-line where the arching tends to be depressed. Hingement extremely simple, hinge-line straight. Anterior cardinal angle less obtuse than the posterior cardinal angle. On the exterior, a sharp V-shaped trough marks the area of hingement. Ventral margin straight, clearly terminated by the beak in front and posteriorly by the sharp arching into the posterior extremity. The ventral margin is inclined towards the hinge-line. Anterior extremity uniformly arcuate from beak to hinge-line. Posterior extremity less broadly arcuate and much shorter in length than anterior extremity. Surface ornaments consist of a beak or extension of the anterior extremity slightly below ventral margin and pointing sharply backward and slightly inclined laterally toward the right. When the carapace is closed there is no opening apparent for the setae to reach the exterior as is commonly seen in *Cypridina*. The surface of the carapace is covered by a mesh-work of punctae which are roughly polygonal and sometimes elongate. No clear evidence of muscle scar observed.

Dimensions.—Maximum length, 1.08 mm.; maximum height, 0.72 mm.; maximum breadth, 0.52 mm.

Generic and specific relationships.—In this form relationships are rather difficult in that the size and position of the beak is different from other forms. The absence of a notch which is so characteristic of all *Cypridea* is to be noted. The general outline is also different. These characters set *Pseudocypridina piedmonti* apart from *Entomoconchus*, *Philomedes*, *Cypridella*, *Cypridellina*, and *Bradycinetus*. The writer is of the opinion that *Cypridea ventroas* var. *bispinosus* Vanderpool should be placed in the genus *Pseudocypridina* rather than in *Cypridea*.

Holotype.—U. S. National Museum, No. 74,473.

Horizon and locality.—Very abundant in the lower shales of the Morrison. Sec. 28, T. 4 N., R. 6 E., Lawrence County, South Dakota.

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UPPER TRINITY MICROFOSSILS FROM SOUTHERN OKLAHOMA

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ABSTRACT

Six new species of foraminifera and four new species of Ostracoda are described and figured. Fifteen other species of microfossils are listed. This fauna was found at one locality in the upper part of the Paluxy formation of Comanchean age, 3 miles north of the town of Marietta in southern Oklahoma.

Surface exposures of Trinity formations along the northern border of the Gulf Coastal Plain do not ordinarily contain many microfossils. The writer was somewhat surprised to find more than twenty-five different forms in samples from one locality in the Trinity in southern Oklahoma.

The locality is a high bluff on U. S. Highway 77, about 3 miles north of Marietta, Love County, Oklahoma. The highway cut is capped by a 15 foot ledge of massive limestone (Goodland limestone of Fredricksburg age). Below the limestone occurs a series of yellow and brown sandy clays and marls containing *Exogyra texana* Roemer and *Ostrea crenulimargo* Roemer. The samples containing the microfossils described in this paper were collected by the writer from the upper part of this fresh exposure of sandy shales.

The basal 2 or 3 feet of the overlying Goodland consists of thin-bedded, nodular, silty limestone and was regarded as the equivalent of the Walnut clays of Texas by Stephenson.[1]

Later, Bybee and Bullard[2] stated that in their opinion this lower part of the limestone ledge should not be separated from the Goodland. At the same time they found a 4-foot marly clay zone 20 feet below the base of the Goodland limestone at an exposure on Red River, north of Gainsville, Texas, that they believed to be the Walnut clay equivalent. The typical Walnut fossils, *Exogyra texana* Roemer and *Gryphea marcouii* Hill and Vaughan, were reported as occurring in the marly clay zone by Bybee and Bullard.

The Walnut clays of northern Texas according to Alexander[3] con-

[1] Stephenson, L. W., Contributions to the geology of northern Texas and southern Oklahoma: *U. S. Geol. Survey, Prof. Paper* 120, 1918.

[2] Bybee, H. P., and Bullard, F. M., The geology of Cook County, Texas: *Texas Univ. Bull.* 2710, 1922.

[3] Alexander, C. I., Ostracoda of the Cretaceous of North Texas: *Texas Univ. Bull.* 2907, 1929.

tains only a few, unrestricted microfossils that range up through the Goodland formation.

The microfauna from the Marietta locality is of a mixed type, that is, partly Fredricksburgian and partly Trinity. The writer now considers that the sub-Goodland sandy shale beds represent the upper part of the Paluxy formation deposited during latest Trinity or earliest Fredericksburg time.

An interesting feature of the fauna found at the Marietta locality of the upper Paluxy was the presence of a few, reworked Paleozoic microfossils. The fact that they were partly broken and iron-stained indicated that they were pre-Comanchean. Prof. R. W. Harris of the University of Oklahoma identified the following species as Middle Pennsylvanian in age:

Tetrataxis lata Spandel
Monoceratina ventralis Roth
Sansabelloides sp.

DESCRIPTION OF SPECIES

FORAMINIFERA

Family LITUOLIDAE

Sub-family HAPLOPHRAGMIINAE

Genus AMMOBACULITES Cushman, 1910

AMMOBACULITES SUBGOODLANDENSIS
Vanderpool, n. sp.

Plate 49, figures 1–3

Test large, flat, much compressed, periphery rounded, early portion of test consisting of four or five tightly coiled chambers rapidly enlarging in size, the later uncoiled portion consisting of one or more chambers gradually increasing in size; chambers lobulate, central part of each chamber concave; sutures distinct, curved; wall coarsely arenaceous; aperture simple, terminal. Maximum length 2.85 mm.; maximum width 2.69 mm. Holotype No. 50 Micropaleontological Collection, University of Oklahoma.

This species is a characteristic form found abundantly in the sandy shales underlying the Goodland limestone. It differs from *Ammobaculites goodlandensis* Cushman and Alexander in its much larger size, stronger test, fewer depressed and lobulate chambers and rounded periphery.

Family REOPHACIDAE

Sub-family REOPHACINAE

Genus REOPHAX Montfort, 1808

REOPHAX SUBGOODLANDENSIS
Vanderpool, n. sp.

Plate 49, figures 4–6

Test large, consisting of four or five thick, nodose chambers gradually increasing in size, arranged in a straight linear series; sutures distinct; wall roughly arenaceous; aperture simple, terminal. Maximum length 3.30 mm.; maximum thickness 1.40 mm. Holotype No. 51 Micropaleontological Collection, University of Oklahoma.

This is another large, distinctive species found abundantly at several localities in the upper Paluxy of southern Oklahoma, directly beneath the Goodland limestone ledge.

Family TEXTULARIIDAE
Sub-family TEXTULARIINAE

Genus TEXTULARIA Defrance, 1824

TEXTULARIA CONICA d'Orbigny
Plate 49, figures 7–9

Textularia conica D'ORBIGNY, *1839*, De la Sagra, Hist. Fis. Pol. Nat. Cuba, "Foraminiferes," p. 143, pl. 1, figs. 19, 20; H. B. BRADY, *1884*, Rep. Voy. Challenger, Zool., vol. 9. p. 365, pl. 43, figs. 13, 14, pl. 113, figs. 1*a*, *b*; CARSEY, *1926*, Texas Univ. Bull. 2612, p. 23, pl. 7, fig. 1.

Textularia sp., MARGARET CARPENTER, *1925*, Texas Univ. Bull. 2544, pl. 17, fig. 15.

This form is assigned to d'Orbigny's *T. conica* because of its shape and size. It occurs as limonitized casts with rounded chambers and distinct sutures.

The writer has found only a few specimens in samples from the Marietta outcrop of the upper Paluxy. The species *T. conica* d'Orbigny has an extremely wide range extending from Washita (upper Comanchean) to Recent. This is the first time, to the author's knowledge, that it has been found in the Trinity. Maximum length 0.38 mm.; maximum width 0.27 mm.; maximum thickness 0.21 mm.

Family ANOMALINIDAE
Sub-family ANOMALININAE

Genus PLANULINA d'Orbigny, 1826

PLANULINA sp.
Plate 49, figures 10, 11

Test small, trochoid, much compressed, convex dorsally, concave ventrally; wall calcareous, perforate. Maximum width 0.41 mm.; maximum thickness 0.12 mm.

This species occurs sparingly in the upper Paluxy at the Marietta locality. Similar forms range all through the Comanchean section.

Family POLYMORPHINIDAE
Sub-family RAMULININAE

Genus RAMULINA, R. Jones, 1875

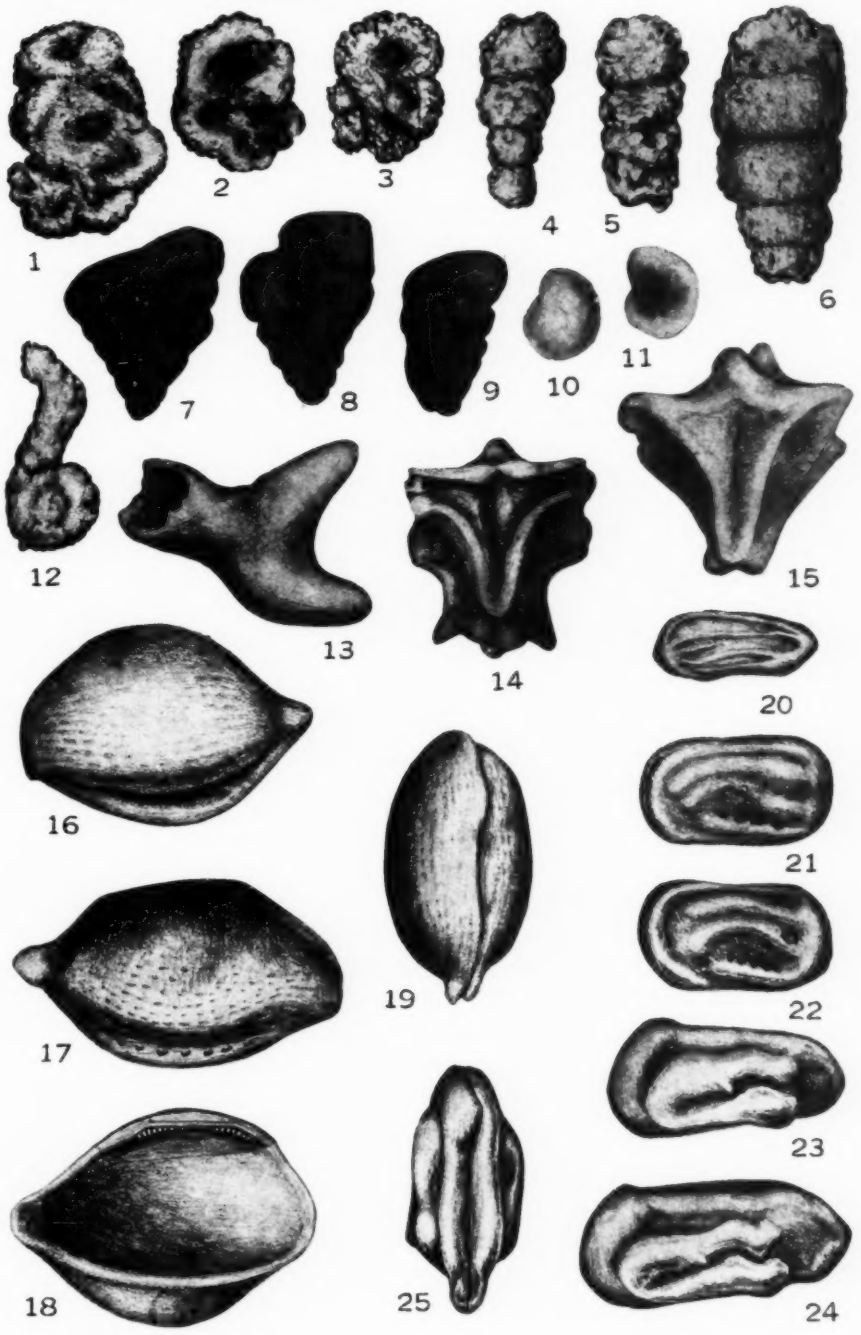
RAMULINA sp.
Plate 49, figure 13

Test irregularly branching, consisting of long stoloniferous tubes; wall calcareous. Length of figured specimen 0.52 mm.; width 0.30 mm.

This form occurs commonly in the sandy shales of the upper Paluxy in southern Oklahoma. Irregularly branching similar types range through the Comanchean and Cretaceous.

EXPLANATION OF PLATE 49

FIGS. 1–3—*Ammobaculites subgoodlandensis* Vanderpool, n. sp., side views. ×12.
4–6—*Reophax subgoodlandensis* Vanderpool, n. sp., side views. ×15.
7–9—*Textularia conica* d'Orbigny, side views. ×65.
10, 11—*Planulina* sp. 10. Dorsal view. 11, ventral view. ×30.
12—*Lituotuba* sp. ×50.
13—*Ramulina* sp. ×40.
14, 15—Vertebral ossicles or skeletal fragments of *Ophiuroidea*.
16–19—*Cytheropteron trinitiensis* (Vanderpool). 16, Left valve view. 17, Right valve view. 18, Interior left valve. 19, Dorsal view. ×75.
20—*Cytherelloidea rhomboidalis* Vanderpool, n. sp. Left valve view. ×40.
21, 22—*Cytherelloidea subgoodlandensis* Vanderpool, n. sp. Left valve views. ×45.
23–25—*Cythereis subgoodlandensis* Vanderpool, n. sp. 23, 24, Left valve views. 25, Dorsal view. ×50.



Vanderpool, Cretaceous microfossils

Family AMMODISCIDAE
Sub-family AMMODISCINAE

Genus LITUOTUBA Rhumbler, 1895

LITUOTUBA sp.
Plate 49, figure 12

Test consists of an undivided tube, closely coiled in early portion and uncoiled in later portion; wall finely arenaceous. Length of figured specimen 0.70 mm.; width of coil 0.30 mm.

This form occurs rarely in the sub-Goodland shales at the Marietta outcrop.

Family LAGENIDAE
Sub-family NODOSARIINAE

Genus VAGINULINA d'Orbigny, 1826

VAGINULINA INTUMESCENS Reuss

Vaginulina intumescens, REUSS, *1863*, Sitz. Akad. Wiss. Wien., vol. 46, p. 49, pl. 4, fig. 2; CUSHMAN and ALEXANDER, *1930*, Contr. Cushman Lab. Foram. Research, vol. 6, pt. 1, p. 5, pl. 2, figs. 1–6.

This variable form occurs abundantly in the upper Paluxy of southern Oklahoma and ranges up through the Fredricksburg (middle Comanchean) of North Texas.

Family ROTALIIDAE
Sub-family DISCORBISINAE

Genus PATELLINA Williamson, 1858

PATELLINA SUBCRETACEA
Cushman and Alexander

Patellina subcretacea CUSHMAN and ALEXANDER, *1930*, Contr. Cushman Lab. Foram. Research, vol. 6, pt. 1, p. 10, pl. 3, fig. 1.

This species occurs very abundantly in the sub-Goodland shales. The Paluxy species varies in height from the low, scale-like form described by Cushman and Alexander from the Goodland of North Texas, to a form practically twice as high and more conical.

OSTRACODA
Family CYTHERELLIDAE

Genus CYTHERELLOIDEA Alexander, 1929

CYTHERELLOIDEA SUBGOODLANDENSIS
Vanderpool, n. sp.
Plate 49, figures 21, 22

Carapace in side view oblong-quadrate; dorsal and ventral margins practically straight; anterior and posterior ends broadly rounded, subequal, the posterior end slightly pointed; valves flat, with a marginal ridge that is broken and offset slightly posterior to the anteroventral angle, connected with the marginal ridge posteriorly and extending across the valve nearly parallel with the dorsal ridge are two subparallel sinuous ridges that terminate anteriorly in a downward slope inside the marginal ridge; muscle spot depressed; surface otherwise smooth. Maximum length 0.58 mm.; maximum height 0.37 mm.; maximum thickness 0.20 mm. Holotype No. 550 Micropaleontological Collection, University of Oklahoma.

This species occurs frequently in the upper Paluxy of southern Oklahoma and is considered a good index fossil. This is the first time, to the author's knowledge, that a member of this recently established new genus has been observed in the Fredricksburg or Trinity.

CYTHERELLOIDEA RHOMBOIDALIS
Vanderpool, n. sp.
Plate 49, figure 20

Carapace in side view elongate, slender, subrhomboidal, highest anteriorly, greatest thickness anteriorly; dorsal margin unevenly arched, ven-

tral margin slightly concave, postdorsal slope straight, short and subparallel to the anteroventral slope, postventral margin a long straight slope and subparallel to the anterodorsal margin; valves subequal, with an uneven marginal ridge that is offset posterior to the anteroventral angle; connecting the marginal ridge anteriorly and posteriorly are two narrow, uneven, subparallel, sinuous ridges, the ventral ridge being shorter and more sinuous, between the two ridges is a short ridge extending posteriorly from the anterior end; surface smooth, convex. Length of figured specimen 0.54 mm.; height 0.19 mm., thickness 0.15 mm. Holotype No. 550 Micropaleontological Collection, University of Oklahoma.

This species is assigned to the genus *Cytherelloidea* because of the quadrate shape and oblique rugations. The convex outline of the form is not characteristic of the genus. This species occurs only rarely in the sub-Goodland sandy shales.

Genus CYTHEROPTERON Sars, 1865

CYTHEROPTERON (EOCYTHEROPTERON) TRINITIENSIS (Vanderpool)

Plate 49, figures 16–19

Cytheridea trinitiensis VANDERPOOL, *1928*, Jour. Paleontology, vol. 2, no. 2, p. 106, pl. 14, figs. 3–6.

Carapace subrhomboidal to subtriangular in side view, height about two-thirds of length, greatest height in middle or slightly anterior to middle, ventral region decidedly inflated, flat to concave below, shell produced posteriorly to form a distinct obtuse beak; dorsal margin strongly but unevenly arched, ventral margin gently curved, anterior end broadly rounded; valves nearly equal, the left slightly overlapping the right especially along the dorsal margin, ventral outline of dorsal overlap straight; hingement of right valve consists of two crenulated crests at opposite ends of the arched hingeline with crenulations most pronounced at extremities and dying out toward center, hingement of larger left valve consists of an overlapping straight dorsal bar with underlying slightly depressed crenulate groove meshing with the crests of the right valve; surface ornamentation consists of broken concentric lines or low ridges, surface smooth when eroded. Length of figured specimens 0.55 mm.; height 0.34 mm.; thickness 0.32 mm. Neotype No. 552 Micropaleontological Collection, University of Oklahoma.

This species occurs very commonly in the upper Paluxy shales in southern Oklahoma and ranges down through the Glen Rose formation (middle Trinity) in Arkansas, Oklahoma and Texas. It has not been found, so far, above the base of the Goodland limestone.

Family CYPRIDAE

Genus CYTHEREIS Jones, 1849

CYTHEREIS SUBGOODLANDENSIS Vanderpool, n. sp.

Plate 49, figures 23–25

Carapace in side view oblong-quadrate, highest anteriorly; dorsal and ventral margins nearly straight, converging posteriorly; anterior end obliquely rounded, a strong rim ex-

tends along the dorsal and ventral borders of the valves, posterior end bluntly acuminate centrally; valves with two prominent slightly curved subparallel warped ridges that extend from the anterior marginal rim two-thirds of the distance across the shell terminating abruptly, a small characteristic node is located on the lower edge of the upper ridge approximately in the middle of the shell; surface otherwise smooth. Maximum length 0.72 mm.; maximum height 0.35 mm.; maximum thickness 0.32 mm. Holotype No. 553 Micropaleontological Collection, University of Oklahoma.

This species is common in the sub-Goodland sandy shales at the Marietta locality and has been found in samples from the same horizon in the upper Paluxy at several stations in southern Oklahoma.

Other ostracodes found in the samples from the upper Paluxy at the Marietta locality include:

Cytheropteron howelli Alexander[4]
Cythereis carpenterae Alexander
Cythereis mahonae Alexander
Cythere concentrica (Reuss)
Cytheridea oliverensis Alexander
Cytheridea amygdaloides var. *brevis* Alexander
Cytherella ovata, Alexander
Paracypris siliqua (Jones and Hinde)
Cytheridea cf. *rotundus* Vanderpool[5]

Ophiuroidea

The vertebral ossicles or skeletal fragments of Ophiuroidea[6] illustrated in Plate 49 figures 14, 15 occur commonly in the upper Paluxy in southern Oklahoma. Similar forms range well up into the Washita (upper Comanchean).

[4] All of the species of this list have been described and figured by Alexander in his paper on the Ostracoda of the Cretaceous of North Texas: *Texas Univ. Bull.* 2907, 1929, except as noted.

[5] *Jour. Paleontology*, vol. 2, no. 2, 1928.

[6] *Jour. Paleontology*, vol. 4, no. 1, pp. 1–14, 1930.

JOURNAL OF PALEONTOLOGY, VOL. 7, NO. 4, PP. 412–422, PL. 50, DECEMBER, 1933

FAUNA OF THE McALESTER SHALE, PENNSYLVANIAN, OF MUSKOGEE COUNTY, OKLAHOMA[1]

CHARLES W. WILSON, JR.
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ABSTRACT

The position of a 3-inch zone of calcareous shale in a cycle of sedimentation is given and the fauna of this thin fossiliferous zone is considered. Seven new species of ostracodes are described.

The fauna discussed in this paper was collected by the writer and T. L. Metcalf during the summers of 1929 and 1930 while engaged in mapping the areal geology of the Muskogee-Porum district, Oklahoma.

The writer wishes to express his gratitude to Dr. J. Brookes Knight for encouragement, helpful criticism, and advice. Dr. G. H. Girty kindly checked most of the writer's identifications of the macrofauna. Helpful suggestions were also made by Dr. L. C. Glenn, Mr. H. D. Miser, Mr. P. V. Roundy, and Mr. T. A. Hendricks.

OCCURRENCE OF THE FAUNA

The fossils here described were all collected from a 3-inch layer of dark-gray, calcareous shale immediately above the McAlester coal. This thin zone yielded by far the best collections of marine fossils found in the McAlester shale of the Muskogee-Porum district. All of the fossils discussed in this paper were collected in the pit of the Trojan Coal Company, sec. 13, T. 11 N., R. 19 E., Muskogee County. It is hoped that the fauna, and especially the unique ostracode fauna, will aid in the recognition and correlation of this characteristic zone in the McAlester shale, both in surface and subsurface work.

The sequence of strata in the McAlester shale bears a striking resemblance to the succession of Pennsylvanian beds in Illinois, described by Weller as constituting a cycle of sedimentation.[2] The writer believes that the five zones, indicated below, represent a similar cycle, but one that developed under conditions of sedimentation different from that of the Illinois cycles. The members of the McAlester cycle, which includes all of the strata between the overlying Savanna sandstone and the base of the lowermost sandstone of the McAlester shale, are as follows:

[1] Published by permission of the Director of the United States Geological Survey.

[2] Weller, J. Marvin, Pennsylvanian cycles of sedimentation: *Jour. Geology*, vol. 38, pp. 97–135, 1930.

Savanna sandstone
McAlester shale

Cycle

5. Carbonaceous, unfossiliferous, gray-black shale with layers of siderite concretions; marine..... 80 feet
4. Calcareous shale, containing abundant marine fossils; marine..... 3 inches
3. McAlester coal; terrestrial. 18 inches
2. Sandy shale; probably terrestrial..... 5 feet
1. Sandstones and intervening sandy shales of the McAlester shale; predominantly terrestrial, but may contain thin layers of marine sediments..... 160 feet

Shale, black..... 130 feet
Hartshorne sandstone

It will be noted that the 130 feet of black shale between the lowermost sandstone of the McAlester shale and the Hartshorne sandstone have been excluded from the cycle, though it is included in the McAlester shale.

MACROFAUNA

The macrofauna found in the calcareous shale member (Zone 4) includes those species that seem to be characteristic of a calcareous-muddy facies; that is, neither a true muddy facies nor a true calcareous or shelly facies. The fauna is largely made up of pelecypods, the great majority of which belong to the Prionodesmacea. Three species of atrematous brachiopods were found. The genera most abundantly represented are *Pteria*, *Deltopecten*, *Leda*, and *Edmondia*.

The faunal list is as follows:

Bryozoa
- *Septopora biserialis*
- *Fenestella* spp.
- *Rhombopora* spp.
- *Prismopora serrata*
- *Prismopora triangulata*

Brachiopods
- *Lingula* sp.
- *Orbiculoidea meekana*
- *Lindstroemella patula*

Pelecypods
- *Prothyris elegans*
- *Edmondia gibbosa*
- *Edmondia? glabra*
- *Nucula anodontoides*
- *Leda bellistriata*
- *Leda inflata*
- *Leda meekana*
- *Leda prolongata*
- *Leda* cf. *L. arata*
- *Schizodus alpinus?*
- *Schizodus* sp.
- *Solenomorpha* sp.
- *Solenomya soleniformis*
- *Solenomya radiata* var.
- *Pteria longa*
- *Pteria sulcata*
- *Pteria ohioensis*
- *Pteria* sp.
- *Deltopecten ? herzeri*
- *Deltopecten occidentalis*
- *Deltopecten scalaris*
- *Deltopecten ? interlineatus*
- *Pleurophorus spinulosus*
- *Pleurophorus oblongus* var.

Gastropods
- *Aclisina* sp.
- *Sphaerodoma* sp.
- *Patellostium marcouianum*
- *Euphemus carbonarius*

Cephalopods
- *Metacoceras cornutum*

Ostracoda
- *Paraparchites* sp.
- *Jonesina gregaria* ? Ulrich and Bassler
- *Kirkbya* sp.
- *Youngiella puncta*, Wilson, n. sp.
- *Youngiella knighti* Wilson, n. sp.
- *Youngiella spicifera* Wilson, n. sp.
- *Bairdia acetalata* Coryell and Billings
- *Bairdia trojana* Wilson, n. sp.
- *Bythocypris pediformis* Knight
- *Bythocypris tomlinsoni* Harlton
- *Bythocypris bisoni* Wilson, n. sp.
- *Bythocypris bullifera* Wilson, n. sp.

Healdia limacoidea Knight
Healdia longa Knight
Waylandella mcalesterensis Wilson, n. sp.
Cytherella missouriensis Knight
Cytherella calcar Harlton

SPECIES OF OSTRACODA

Family KLOEDENELLIDAE Ulrich and Bassler

Genus JONESINA Ulrich and Bassler

JONESINA GREGARIA ? Ulrich and Bassler

Beyrichiella gregaria, ULRICH and BASSLER, *1906*, U. S. Nat. Mus. Proc., 1446, vol. 30,p. 157, pl. 11, fig. 18.
Jonesina gregaria ULRICH and BASSLER, *1908*, U. S. Nat. Mus., Proc., 1646, vol. 35, pl. 44, fig. 6.

This species is represented in the collection from the McAlester shale by only one incomplete specimen.

Family YOUNGIELLIDAE Kellett

Genus YOUNGIELLA Jones and Kirkby

Jones and Kirkby[3] described the genus "*Youngia*," which they included in the family Cytheridae on the basis of denticulated hinge line, as follows:

> "Minute, suboblong, dorsal border long and straight, ends rounded; ventral border nearly or quite straight, and sloping up to each extremity. Dorsal border finely toothed along its whole length (after the manner of *Arca*); shell thick; surface smooth, or faintly reticulated."

The only species described, "*Youngia rectidorsalis*" Jones and Kirkby, was figured but there was no description.

In 1886[4] "*Youngia*" was again described more or less as before with the additional information that the specimens were collected from the Upper Carboniferous limestone series of West Scotland.

In 1895[5] "*Youngia*" was replaced by *Youngiella* as the former was preoccupied. The finding of other specimens of the same species, as previously described, from the Yoredale series (Carboniferous limestone series) from Downholme was mentioned.

In the 1923 report of the Maryland Geological Survey Ulrich and Bassler[6] included the genus in the family Kirkbyidae.

A revised description of *Youngiella* is given as follows: Carapace subrectangular; maximum length approximately midway between dorsal and ventral margins; maximum height and breadth approximately midway between anterior and posterior extremities; dorsal margin straight; ventral margin usually straight, curves upward to both extremities; anterior cardinal angle approximately 90°; posterior cardinal angle approximately 120°; posterior extremity usually higher than anterior extremity; curve of posterior extremity with pronounced backward swing; essentially equivalved; articulation of valves by means of alternating series of teeth and sockets that extend the entire length of hinge line; surface smooth, pitted, or otherwise ornamented; narrow, smooth border that rises above general level of the valve usually present along the free margins of the valve, being more

[3] Jones and Kirkby, *Geologists Assoc., Proc.*, vol. 9, p. 515, 1885.
[4] Jones and Kirkby, *Quart. Jour. Geol. Soc. London*, vol. 42, p. 507, 1886.
[5] Jones and Kirkby, *Annals and Mag. Nat. Hist.*, 6th ser. vol. 16, p. 456, 1895.
[6] Ulrich and Bassler, Silurian: *Maryland Geol. Survey*, p. 315, 1923.

prominent on the margin of the posterior extremity; muscle spot may or may not be present.

The family Youngiellidae was proposed by Kellett[7] to include two genera, *Moorites* Coryell and Billings and *Youngiella* Jones and Kirkby. The most diagnostic character of the members of this new family is the series of fine, regularly alternating teeth and sockets that extend the full length of the hinge line (see figure 1). These teeth were first discovered by Jones and Kirkby in 1886 at which time they described and illustrated the genotype, *Youngiella* ("*Youngia*" *rectidorsalis*. The next find of the *Youngiella*-type of dentition was made independently by Knight and by the writer in 1929 while studying collections of Pennsylvanian Ostracoda from Missouri and Oklahoma, respectively. Knight found this dentition on specimens of "*Glyptopleurina*?" *minuta* Warthin. The writer found the same dentition on the three new species of *Youngiella* described in this paper. No other mention of the finding of similar dentition is known.

In 1930 Warthin[8] described a species that he called "*Glyptopleurina*? *minuta*." In 1932 Coryell and Billings[9] identified specimens in their collections as being similar to Warthin's species. In this study the authors proposed a new genus, *Moorites*, which included at that time three species, *M. hewetti*, *M. minutus* (Warthin), and *M. truncatus*. Later another species, *M. parallelus*[10] was added.

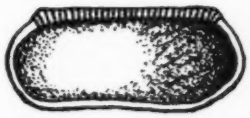

FIGURE 1—Diagrammatic sketch of the interior of a valve of *Youngiella* showing the alternating series of teeth and sockets.

Recently Kellett[11] proposed the new family Youngiellidae, in which *Moorites* is accepted as a valid genus, and the genotype *M. hewetti* Coryell and Billings is placed in the synonymy of *M. minutus* (Warthin) along with *M. truncatus* Coryell and Billings.

It is believed that the characteristic *Youngiella* dentition is incompatible with the Kirkbyidae and that a new family, as proposed by Kellett, is needed to receive such genera as possess this dentition.

The present writer is somewhat skeptical as to the validity of *Moorites* as distinct from *Youngiella*, since he is unable to recognize any marked difference between the two except the elongate, looplike costa present on the valves of the former. Ornamentation, such as pitting, cannot be limited to *Moorites*, as Jones and Kirkby in their original description of the genotype of *Youngiella*

[7] Kellett, Betty, *Jour. Paleontology*, vol. 7, no. 1, pp. 103–105, March, 1933.

[8] Warthin, Alfred S., Jr., Micropaleontology of the Wetumka, Wewoka, and Holdenville formations: *Oklahoma Geol. Survey, Bull.* 53, p. 67, 1930.

[9] Coryell, H. N., and Billings, Gladys D., Pennsylvanian Ostracoda of the Wayland shale of Texas: *Am. Midland Naturalist*, vol. 13, p. 182, 1932.

[10] Coryell, H. N., and Sample, C. H., A study of the Ostracoda fauna of the East Mountain shale, Mineral Wells formation, Texas: *Am. Midland Naturalist*, vol. 13, p. 257, 1932.

[11] Kellett, Betty, *Jour. Paleontology*, vol. 7, no. 1, pp. 103–105, March, 1933.

state that the surface may be "faintly reticulated." Such surficial ornamentation is not thought to be sufficient basis for generic separation. For this reason *Moorites* is here considered a synonym of *Youngiella*.

The following species, all but the first from the Pennsylvanian of North America, are included in *Youngiella*: *Youngiella rectidorsalis* Jones and Kirkby, 1886, genotype; *Y. minuta* (Warthin), 1930; *Y. hewetti* (Coryell and Billings), 1932; *Y. truncata* (Coryell and Billings), 1932; *Y. parallela* (Coryell and Sample), 1932; *Y. puncta* Wilson, n. sp.; *Y. spicifera* Wilson, n. sp.; *Y. knighti* Wilson, n. sp.

YOUNGIELLA PUNCTA Wilson, n. sp.
Plate 50, figures 4*a–d*

Carapace subrectangular, corners rounded; maximum length midway between dorsal and ventral margins; maximum height and breadth are both midway between the anterior and posterior extremities; dorsal margin usually straight, rarely slightly arched near the middle; dorsal aspect shows both valves tapering from the line of greatest breadth at the center of the valves to the blunt anterior and posterior extremities, of which the latter is the broader; ventral margin usually straight, but rounds sharply at the anterior and less sharply at the posterior; anterior extremity is a fairly symmetrical curve with the anterior cardinal angle sharper than the anterior ventral angle; posterior extremity curves outward a short distance from the posterior cardinal angle of approximately 120° before abruptly swinging backward to meet the ventral angle; carapace equivalved. The articulation of the valves is by means of a series of approximately 35 alternating teeth and sockets, which extend the entire length of the hinge line and a short distance around both cardinal angles. The shell is relatively thicker along the hinge-line, especially at the cardinal angles where the teeth and sockets are much longer. The surface is marked by numerous small pits. In a majority of the specimens the pits are approximately equidimensional and regularly spaced; in some, however, the pits, especially those near the center of the valve, are elongated and are oriented to form concentric rows of inequidimensional pits. The anterior and posterior extremities and the ventral margins are bordered by a narrow, smooth border that rises above the general level of the valve.

Measurements of an average specimen: Length, 0.35 mm.; height, 0.18 mm.; breadth, 0.14 mm.

This abundant species is very similar to *Youngiella parallela* (Coryell and Sample), but the deep, clearly marked pits ornamenting the surface of *Y. puncta* are quite different from the "poorly defined pits"[12] of *Y. parallela*, which are apparently not sufficiently well developed to be shown on the accompanying figure. The only alternative to describing *Y. puncta* as a distinct species is to assume that the poor definition of the pits on *Y. parallela* is due to poor preservation of the known specimens.

[12] Coryell, H. N., and Sample, C. H., *Op. cit.* p. 257.

McAlester shale, 3-inch zone above McAlester coal, Muskogee County, Oklahoma.

YOUNGIELLA SPICIFERA Wilson, n. sp.
Plate 50, Plates 8*a*, *b*

Carapace subtrapeziform, with posterior ventral corner rounded; maximum length slightly more than half the distance between the dorsal and ventral margins; maximum height approximately three-fifths of the distance between the anterior and posterior extremities; dorsal margin is straight for the entire distance; ventral margin is straight, converging anteriorly toward the dorsal margin and curving sharply upward to join the posterior extremity; anterior extremity is a slightly convex curve making sharp angles with both the dorsal and ventral margins. The anterior cardinal angle is approximately 90°, while the anterior ventral angle is greater than 90°. This difference in angles results from the divergence of the two margins. The posterior extremity leaves the dorsal margin at an angle of approximately 130° and curves a short distance before swinging back to merge with the ventral margin. Carapace equivalved. The dentition along the hinge-line is similar to that of *Y. puncta*. The surface is reticulated with small pits of which the ones near the center are elongated and oriented into concentric rows. The anterior and posterior extremities and the ventral margin are bordered by a narrow, smooth rim, which rises above the general level of the valve. This border is widest around the posterior extremity. At the anterior ventral corner of each valve a small spine protrudes anteriorly.

Measurements of holotype: Length 0.27 mm.; height 0.14 mm.

McAlester shale, 3-inch zone above McAlester coal, Muskogee County, Oklahoma.

YOUNGIELLA KNIGHTI Wilson, n. sp.
Plate 50, figures 2*a–c*

Carapace subrectangular, corners rounded; maximum length midway between dorsal and ventral margins, height uniform for most of the length; maximum breadth slightly more than half the distance between the anterior and posterior extremities; dorsal margin straight for the entire distance; ventral margin straight, curving gradually upward to join the anterior extremity and abruptly upward to join the posterior extremity; ventral aspect shows the valves gradually increasing in width from the blunt posterior extremity up to the line of greatest breadth and then tapering off to a less blunt anterior extremity; anterior extremity leaves the dorsal margin at an angle greater than 90° but soon turns to join the ventral margin; posterior extremity forms an angle of approximately 140° with the dorsal margin and extends a short distance posteriorly before abruptly swinging back to meet the ventral margin; carapace equivalved; dentition is similar to that of *Y. puncta;* surface perfectly smooth with no ornamentation.

Measurements of an average specimen: Length, 0.35 mm; height, 0.17 mm; breadth, 0.12 mm.

This species resembles *Y. rectidorsalis* Jones and Kirkby very much in regard to general outline and lack of ornamentation. There are no descriptions of this species that would help determine the details of the specific characters of the genotype and the published drawings are diagrammatic and hence of no use for specific determination. *Y. rectidorsalis*, however, may be faintly reticulated as mentioned by Jones and Kirkby. The difference in geographical distribution and geological horizon would point to the improbability of the identity of the two.

McAlester shale, 3-inch zone above McAlester coal, Muskogee County, Oklahoma.

Family BAIRDIIDAE

Genus BAIRDIA McCoy

BAIRDIA ACETALATA Coryell and Billings

Bairdia acetalata CORYELL and BILLINGS, *1932*, Am. Midland Naturalist, vol. 13, p. 173.

This species is represented in the collection by a single specimen.

BAIRDIA TROJANA Wilson, n. sp.

Plate 50, figures 9*a–c*

Carapace elongate; maximum length midway between dorsal and ventral margins; dorsal margin is straight; dorsal aspect shows a slender, lanceolate form with subparallel sides that taper to sharp points at both ends; ventral margin is straight; anterior extremity is a uniformly rounded curve between the subparal-

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EXPLANATION OF PLATE 50

FIGS. 1*a–d*—*Healdia limacoidea* Knight. *a*, Right valve of female, ×35. *b*, Dorsal aspect of female, ×35. *c*, Right valve of male, ×35. *d*, Dorsal aspect of male, ×35.

2*a–c*—*Youngiella knighti* Wilson, n. sp. *a*, Left valve, ×50. *b*, Left valve, ×50. *c*, Ventral aspect, ×50.

3*a*, *b*—*Waylandella mcalesterensis* Wilson, n. sp. *a*, Left valve, ×40. *b*, Left valve, ×35. Note the posterior concentric ridge.

4*a–d*—*Youngiella puncta* Wilson, n. sp. *a*, Dorsal aspect, ×50. *b*, Right valve, ×35. *c*, Right valve, ×35. *d*, Left valve, ×50.

5*a–c*—*Bythocypris bullifera* Wilson, n. sp. *a*, Right valve, ×40. *b*, Dorsal aspect, ×35. *c*, Right valve, ×35. Note the small, rounded knob, or tubercle, near the posterior extremities of the specimens of 5*a* and *c*.

6*a–c*—*Bythocypris bisoni* Wilson, n. sp. *a*, Right valve, ×35. *b*, Left valve, ×35. *c*, Dorsal aspect, ×35.

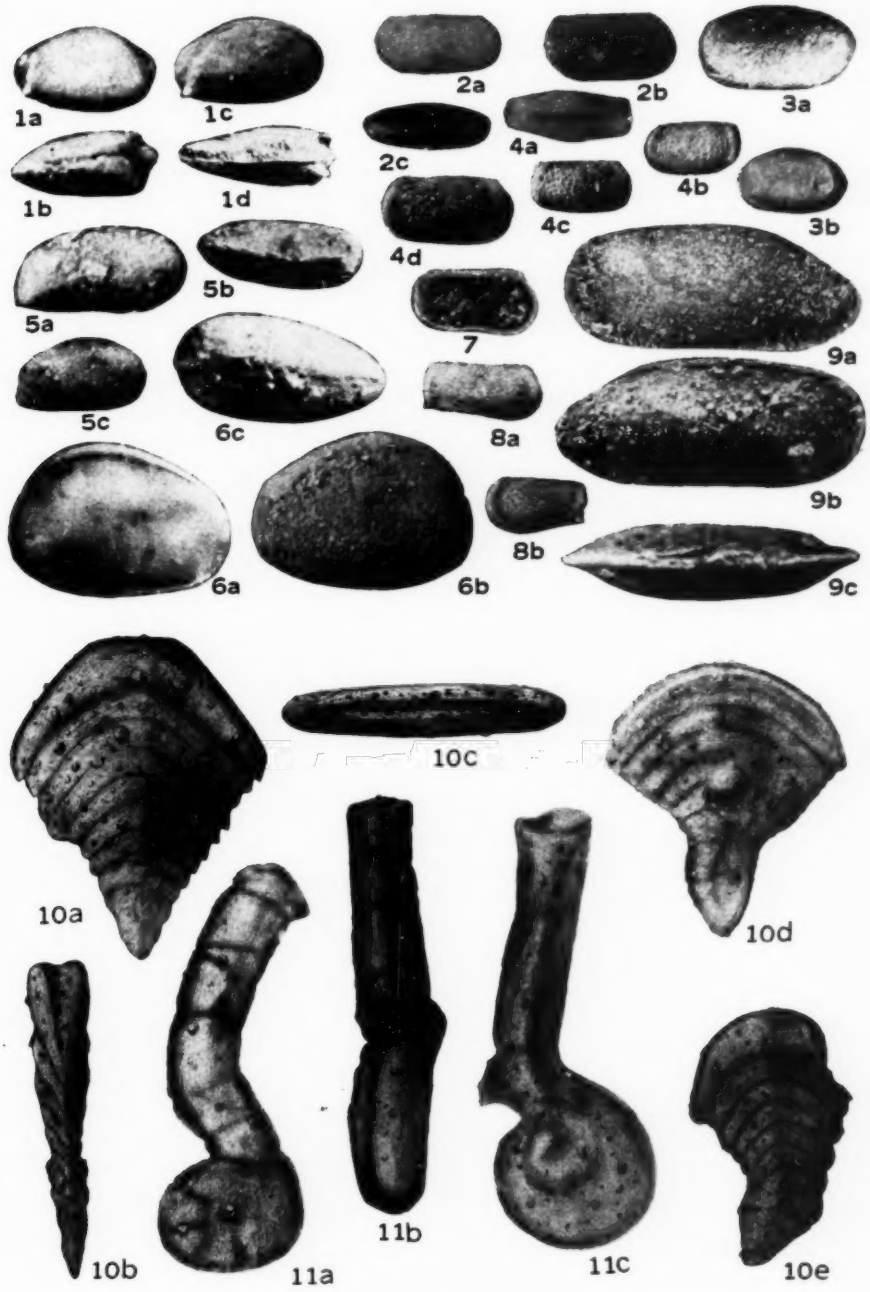
7—*Youngiella minutus* (Warthin), ×35. (This specimen was loaned to the writer by Dr. J. Brookes Knight.) Note the alternating series of teeth and sockets along the hinge-line.

8*a*, *b*—*Youngiella spicifera* Wilson, n. sp. *a*, Left valve, ×50. *b*, Right valve, ×50. Note the small ventral anterior spine.

9*a–c*—*Bairdia trojana* Wilson, n. sp. *a*, Left valve, ×35. *b*, Right valve, ×35. *c*, Ventral aspect, ×35.

10*a–e*—*Semitextularia thomasi* Miller and Carmer, n. sp., ×90. *a–c*, Three views of a typical specimen. *d*, Another specimen, the adapical portion of which is abnormally narrow. *e*, A third specimen which is curved in the plane of the flattening. *Devonocidaris jacksoni* zonule, near the middle of the Cerro Gordo member of the Hackberry (Upper Devonian) at Birds Hill, four miles southwest of Rockford, Iowa.

11*a–c*—*Lituotuba dubia* Miller and Carmer, n. sp., ×120. *a*, A specimen in which the uncoiled portion of the test is distinctly curved and is marked by numerous constrictions. *b*, *c*, Two views of a slightly distorted specimen. *Devonocidaris jacksoni* zonule, near the middle of the Cerro Gordo member of the Hackberry (Upper Devonian) at Birds Hill, four miles southwest of Rockford, Iowa.



Wilson, Pennsylvanian ostracodes
Miller and Carmer, Devonian foraminifera

lel margins; straight posterior dorsal slope extends from the dorsal margin to a rounded beak about halfway between the dorsal and ventral margins where it meets the convex posterior ventral curve; inequivalved, overlap of right valve by left valve slight along dorsal margin and not discernible along the posterior dorsal slope; overlap along the ventral margin limited to central portion; surface is smooth.

Measurements of holotype: Length 1.1 mm.; height, 0.48 mm.; breadth, 0.3 mm.

This rather rare species resembles *Bairdia acetalata* Coryell and Billings in certain general respects. It differs in the much less pronounced dorsal overlap, especially along the posterior dorsal slope where the overlap may be partially or completely absent; in possessing subparallel dorsal and ventral margins; and in having the posterior beak formed almost equally of two valves rather than a predominating left valve.

McAlester shale, 3-inch zone above McAlester coal, Muskogee County, Oklahoma.

Genus BYTHOCYPRIS Brady

BYTHOCYPRIS PEDIFORMIS Knight

Bythocypris pediformis KNIGHT, *1928*, Jour. Paleontology, vol. 2, p. 326.
Bythocypris parallela KNIGHT, *1928*, Jour. Paleontology, vol. 2, p. 327.

This species is well represented in the collection from the McAlester shale. In a paper by Knight[13] he describes two species, *Bythocypris pediformis* and *B. parallela*, which differ only in relative amount of dorsal arching, prominence of the beak, and breadth. In 1930 Warthin[14] placed *B. parallela* in the synonomy of *B. pediformis*. On the basis of the specimens in the collection of the present writer and following correspondence with Dr. Knight it is believed that *B. pediformis*, which possesses more dorsal arching, a more prominent beak, and greater breadth. and *B. parallela* (male) are sexual dimorphants of the same species. Similar cases of sexual dimorphism have been described by Kellett[15] and Alexander.[16]

BYTHOCYPRIS TOMLINSONI Harlton

Bythocypris tomlinsoni HARLTON, *1929*, *Am. Jour. Sci.*, vol. 18, p. 270.

This species is well represented in the writer's collection.

BYTHOCYPRIS BISONI Wilson, n. sp.

Plate 50, figures 6*a–c*

Carapace sub-semicircular; maximum length is one-third of the distance between dorsal and ventral margins; line of maximum height intersects line of maximum breadth about three-fifths of the distance between the anterior and posterior extremities; dorsal margin has a pronounced, slightly posterior hump suggestive of the arched back of a bison; dorsal aspect shows both valves tapering gently from the line

[13] Knight, J. Brookes, Some Pennsylvanian ostracodes from the Henrietta formation of eastern Missouri: *Jour. Paleontology*, vol. 2, pp. 229–337, 1928.

[14] Warthin, Alfred S., Jr., *Op. cit.*, p. 74.

[15] Kellett, Betty, The ostracode genus *Hollinella: Jour. Paleontology*, vol. 3, pp. 196–217, 1929.

[16] Alexander, C. I., Sexual dimorphism in fossil Ostracoda: *Am. Midland Naturalist*, vol. 13, pp. 302–311, 1932.

of maximum breadth toward the anterior, but tapering abruptly toward the blunt posterior; ventral margin is a convex curve with a sharp upward swing near the posterior extremity; anterior extremity is a fairly symmetrical curve, but with the anterior cardinal angle greater than the anterior ventral angle; posterior ventral angle is a smooth curve up to the line of maximum length where it abruptly joins the blunt posterior dorsal curve that forms the posterior slope of the pronounced dorsal hump; inequivalved, left valve being larger and overlapping the right on all sides; overlap is least at the anterior extremity and most pronounced on the dorsal and ventral margins; surface is smooth; an almost centrally located, discolored muscle spot is to be seen on several of the specimens.

Measurements of an average specimen: Length, 0.85 mm.; height, 0.6 mm.; breadth, 0.4 mm.

This very characteristic species is abundantly represented in the collection. In certain respects it resembles *Bythocypris semicirculus* Coryell and Sample, but it differs from this species in possessing extremely pronounced dorsal and ventral overlap, a more precipitous posterior extremity, and in being much larger.

McAlester shale, 3-inch zone above McAlester coal, Muskogee County, Oklahoma.

BYTHOCYPRIS BULLIFERA Wilson, n. sp.

Plate 50, figures 5*a–c*

Carapace an elongate ellipse with an approximate right angle at the posterior ventral angle. Maximum length is within the ventral third of the carapace. Dorsal margin is straight or only slightly curved between extremities. Dorsal aspect shows an almost symmetrical ellipse with the posterior extremity only slightly more blunt and with greater breadth than the anterior extremity. Ventral margin is straight between the gentle upward swing at the anterior ventral angle and the abrupt reverse turn at the posterior ventral angle. Anterior extremity is a symmetrical curve that is more acute than a semicircle. Posterior extremity turns off the ventral margin at an angle slightly less than 90° and from there swings uniformly into the dorsal margin. Inequivalved. Left valve overlaps right valve on all sides. Near the posterior extremity of each valve there is a small, rounded knob, or tubercle. Surface is otherwise smooth.

Measurements of the holotype: Length, 0.64 mm.; height, 0.31 mm.; breadth, 0.26 mm.

This species resembles *Bythocypris pediformis* Knight in outline and general characters but differs from this species and other more or less similarly shaped ones in the possession of the posterior rounded knob, or tubercle.

This tubercle is a source of puzzlement to the writer as it resembles the "eye spots" so characteristic of *Leperditia*, etc. in shape, size, and position. An attempt was made to determine whether the carapace was thinner in

the tubercle, but no significant results were obtained. Additional data contributed by study of subsequent specimens possessing this feature may prove the knob to be an "eye spot" and hence the postulated conventional orientation of *Bythocypris*, or some new genus, incorrect.

McAlester shale, 3-inch zone above McAlester coal, Muskogee County, Oklahoma.

Genus HEALDIA Roundy

HEALDIA LIMACOIDEA Knight

Plate 50, figures 1*a–d*

Healdia limacoidea KNIGHT, *1928*, Jour. Paleontology, vol. 2, p. 333.

This species is abundantly represented in the writer's collection. During the early stages of the study of these specimens the writer believed that he was dealing with two species, *H. limacoidea* Knight and an undescribed, closely associated one. The *H. limacoidea* as described and illustrated by Knight possesses greater breadth, more pronounced dorsal arching, and a pronounced extension of the anterior dorsal portion of the right valve beyond the corresponding portion of the left valve. The closely associated type occurring in the McAlester shale collection is characterized by narrower body, less pronounced dorsal arching, and a uniform anterior dorsal curve.

After study and comparison of these two types the writer concludes that both types are sexual dimorphants of the same species, *H. limacoidea* Knight being the female and the closely associated type the male.

HEALDIA LONGA Knight

Healdia longa KNIGHT, *1928*, Jour. Paleontology, vol. 2, p. 332.

This species is well represented in the writer's collection. The specimens were checked with paratypes in the collection of Dr. Knight.

Genus WAYLANDELLA Coryell and Billings

WAYLANDELLA MCALESTERENSIS

Wilson, n. sp.

Plate 50, figures 3 *a*, *b*

Carapace elliptical with subparallel sides; maximum length midway between the dorsal and ventral margins; maximum height approximately midway between the anterior and posterior extremities; dorsal margin is straight or with a slight curve; ventral margin is similarly straight or with a slight curve, but rounds abruptly at the anterior and posterior extremities; anterior extremity is semicircular; both posterior dorsal and posterior ventral angles swing gradually backward and meet in a point about midway between dorsal and ventral margins; inequivalved, left valve overlaps the right valve on all sides, overlap being greater on the dorsal and ventral margins; near the posterior extremity there is a concentric ridge that is homologous to the spine-base common to many species of *Healdia* and *Waylandella;* surface is otherwise smooth.

Measurements of the holotype: Length, 0.43 mm.; height 0.27 mm.

McAlester shale, 3-inch zone above McAlester coal, Muskogee County, Oklahoma.

Family CYTHERELLIDAE Sars

Genus CYTHERELLA Jones

CYTHERELLA MISSOURIENSIS Knight

Cytherella missouriensis KNIGHT, *1928*, Jour. Paleontology, vol. 2, p. 334.

Several specimens belonging to this species were found in the McAlester shale. These specimens were checked with paratypes at Yale University.

CYTHERELLA CALCAR Harlton

Cytherella calcar HARLTON, *1928*, Jour. Paleontology, vol. 2, p. 141.

Cytherella calcar HARLTON, *1929*, Texas Univ. Bull. 2901, p. 161.

This species is represented by only one specimen that corresponds closely to the holotype in the U. S. National Museum.

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DEVONIAN FORAMINIFERA FROM IOWA

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ABSTRACT

Foraminifera have been reported from Devonian limestones of South Devon, England, the *Stringocephalus* limestone (Middle Devonian) and *Clymenia* Kalk (Upper Devonian) of Germany, the Nemingha (Middle Devonian) of New South Wales, the Middle Devonian of Asia Minor, the Hackberry (Upper Devonian) of Iowa, and the Bailey (Lower Devonian) of Missouri. Only thirteen Devonian species have been described; five from New South Wales, seven from Germany, and one from Iowa. In the present paper, the species already known from the Devonian (Hackberry) of Iowa is discussed, and two new forms from the same horizon and locality are described and illustrated. One of the latter, though specifically new, is referable to the genus *Lituotuba;* the other represents a new genus, *Semitextularia*, allied to *Spiroplectammina*.

So few foraminifera have been described from Devonian strata anywhere in the world, that the discovery of one or two additional representatives seems worth recording, particularly since one of them represents a previously unknown genus. The scarcity of foraminifera in the Devonian, implied by the small number of species that have been described, must be only apparent and not real, for numerous forms are known from the Silurian and Mississippian of both Europe and North America.

The earliest reference to Devonian foraminifera is by John Phillips.[1] In a paper which was presented orally in 1845 but apparently was not published until 1849, he discussed in a general way the microfaunas of Yorkshire known at that time, and mentioned that "the limestone of South Devon [Devonian] and the Silurian limestones contain traces of this widely diffused class of Microzoa [Foraminifera]" but gave no further information in regard to the Early Paleozoic forms. Much later (1892) these Devonian limestones of South Devon were studied microscopically by Wethered,[2] and in discussing specimens of the "Goniatite limestone" (Upper Devonian) from a quarry near Chudleigh, he stated:

> The specimens collected as typical of this limestone show it to be quite different in structure from the beds below. There is a fine crystalline groundmass in which are several fragmentary remains of organisms. One of these appears to be a foraminifer, and it is especially interesting as being the only one found in my slides of the South Devon Limestones. The

[1] Phillips, John, On the remains of microscopic animals in the rocks of Yorkshire: *Geol. and Polytech. Soc. of the West Riding of Yorkshire, Proc.*, vol. 2, p. 276, 1849.

[2] Wethered, Edw., On the microscopic structures and residues insoluble in hydrochloric acid in the Devonian limestones of South Devon: *Quart. Jour. Geol. Soc. London*, vol. 48, p. 380, 1892.

Goniatite Limestone seems to have been formed by an accumulation of small shells, foraminifera, etc., which have been filled in with a fine calcareous mud.

Wethered did not describe the foraminifera he observed, nor did he refer it to any genus or give any indication as to its nature, and in so far as we have been able to ascertain, neither descriptions nor illustrations of the Devonian foraminifera of southwestern England have ever been published.

Foraminifera were not recorded from the Devonian of continental Europe until long after Phillips had noted their occurrence in the limestones of South Devon. In 1858 and again in 1862, Ehrenberg[3] referred to the foraminifer genus *Miliola* some small, subspherical, straight and spirally ribbed, hollow, calcareous fossils from the Lower Devonian shales near Leningrad; these are now generally regarded as doubtful oogonia and are referred to several genera, which are probably related to the modern *Chara*. In 1879, Schlüter[4] described some peculiar bulbous structures, 4 or 5 mm. in diameter, from the Middle Devonian of Gerolstein, in the Eifel region of Germany, and concluded that they were foraminifer. He recognized, however, that they were not at all similar or closely related to any foraminifera known at that time, and he proposed a new generic term for his single species, *Coelotrochium decheni*. Dr. Joseph A. Cushman has recently written us that Mrs. Richter, wife of Dr. Rudolf Richter of the Natural History Museum at Frankfurt, has restudied Schlüter's specimens and has ascertained that they are not foraminifera.

Shortly after the appearance of Schlüter's paper, Terquem[5] figured and briefly described a few foraminifera from the Middle Devonian of Gerolstein and Paffrath, both in the Eifel district of western Germany. A longitudinally ribbed, submoniliform specimen found between the costae of an *Atrypa reticularis* from near Gerolstein was described as a new species, *Placopsilina costata*. In the sand filling of a *Megalodon* from Paffrath, Terquem found many small casts apparently representing both foraminifera and ostracodes, but in general indeterminable. Numerous small spheroids more or less covered with small spines were referred to the genus *Orbulina;* a pyriform body was assigned to *Lagenulina* (a subgenus of *Lagena*); a cistellarian was compared to *Cistellaria vestuta* of the Jurassic; a fusiform body was regarded as a representative of *Fusulina;* and numerous small globular bodies consisting of two or three

[3] Ehrenberg, C. G., Über fortschreitende Erkenntniss massenhafter mikroskopischer Lebensformen in den untersten silurischen Tonschichten bei Petersburg: *Monatsberichte der K. Preuss. Akad. der Wissenschaften zu Berlin*, 1858, pp. 303–304, 311, 1859; Über die obersilurischen und devonischen mikroskopischen Pteropoden, Polythalamien und Crinoiden bei Petersburg in Russland: *Monatsberichte der K. Preuss. Akad. der Wissenschaften zu Berlin*, 1862, pp. 599–600, 601, figs. 7–11, 1863.

[4] Schlüter, Clemens, *Coelotrochium decheni*, eine Foraminifere aus dem Mitteldevon: *Zeit. Deutschen geol. Gesell.*, Bd. 31, pp. 668–675, 1879.

[5] Terquem, O., Observation sur quelques fossiles des époques primaires: *Soc. Géol. de France, Bull.*, ser. 3, vol. 8, pp. 414–418, pl. 11, 1880.

chambers were assigned to *Globigerina*. Terquem's descriptions of these forms are short, some of his identifications are obviously wrong, and it is of course not possible to tell from his figures (lithograph drawings) how accurate his observations were. Chapman[6] has stated that he is "inclined to think that Terquem's prickly Orbulinae may have more than a fancied relationship to the orbicular radiolarians," but he has refrained from expressing an opinion in regard to the rest of the identifications except to state that Terquem's paper is an "authentic record" of Devonian foraminifera.

Terquem's work stimulated Chapman to disintegrate and examine for microfossils, fragments of limestone that he gleaned from some macrofossils of the Devonian of Germany, that were in the National Museum, Melbourne. As was to be expected, he found a small but representative series of Foraminifera, Radiolaria, Ostracoda, etc. In 1921, he[7] published a study of most of these fossils, and in it he described three new species of foraminifera (*Cassidulina devonica*, *Polymorphina archaica*, and *P. seminis*) from the Middle Devonian (*Stringocephalus* limestone) at Paffrath and identified *Truncatulina lobatula* (Walker and Jacob) and a "rather tumid variety" of *Endothyra bowmani* Philips from the same horizon and locality and *Ammodiscus incertus* (d'Orbigny) from the Upper Devonian (*Clymenia* Kalk) of Schübelhammer, Bavaria.

Chapman[8] has also published an account of some Devonian foraminifera from the Tamworth District, New South Wales. In thin-sections of the Nemingha limestone (Middle Devonian), he claims to have recognized *Valvulina plicata* Brady and *V. bulloides* Brady, both originally described from the Carboniferous; and he has described three new species from the same source: *Psammosphaera neminghensis*, *Valvulina oblonga*, and *Pulvinulina bensoni*. Chapman's descriptions of these forms are short, and as he points out "studying foraminifera from rock-slices, without accompanying specimens showing the exterior of the test, is not entirely satisfactory." Nevertheless, it is quite clear that none of the foraminifera described by him from the Devonian of Australia is at all comparable to those known from strata deposited during the same period in North America.

Recently Maître[9] has recorded the

[6] Chapman, Fredk., Devonian Foraminifera, Tamworth District, New South Wales, Appendix i to W. N. Benson's The Geology and Petrology of the Great Serpentine Belt of New South Wales: *Linnean Soc. of New South Wales, Proc.*, vol. 43, p. 386, 1918.

[7] Chapman, Fredk., On Ostracoda, Foraminifera, and some organisms related to Calcisphaerae from the Devonian of Germany: *Roy. Microscopical Soc. Jour., Trans. for 1921*, pp. 329–340, pl. 8.

[8] Chapman, Fredk., Devonian Foraminifera; Tamworth District, New South Wales, Appendix i to W. N. Benson's The Geology and Petrology of the Great Serpentine Belt of New South Wales: *Linnean Soc. of New South Wales, Proc.*, vol. 43, pp. 385–391, pls. 39–41, 1918.

[9] Maître, D. Le, Sur la présence d'algues et de foraminifères du genre *Endothyra* dans des calcaires d'âge dévonien: *Comptes Rendus des Séances de l'Acad. des Sci.*, tome 190, pp. 764–765, 1930; and Observations sur les Algues et les Foraminifères des calcaires dévoniens: *Soc. géol. du Nord Annals*, tome 55, pp. 45–49, 1930.

occurrence of foraminifera in the Devonian of Asia Minor. In thin-sections of Middle Devonian limestone from near Bartin, Turkey, she recognized the presence of numerous foraminifera among which are representatives of *Endothyra*, *Archaediscus* and *Globigerina*?. Of these, only the first is abundantly represented, and at least two forms of it are present; these may, however, represent simply another case of dimorphism which is so common among the foraminifera. Unfortunately, the specimens could be studied only in thin-sections and hence specific descriptions were not attempted; therefore adequate comparisons with comparable forms from other regions are not possible. Maître mentions also that *Endothyra* has been recognized before in "le calcaire de la Zone d'Etroeungt, à la limite entre Dévonien et Carbonifère," but we have not been able to find the original record of this occurrence.

With the exception of the erroneous reference of such form as as *Receptaculites*, *Pasceolus* [=*Cyclocrinites*], and *Calcisphaera* [=*Trochiliscus*] to the order Foraminifera,[10] foraminifera were not reported from the Devonian strata of North America until 1920. In that year, Bagg[11] identified forty-five species and varieties of foraminifera from thin-sections of chert pebbles from the Bonaventure conglomerate of Gaspé. This conglomerate was regarded at that time as either Late Devonian or Early Mississippian in age, but it has since been shown to be Mississippian. Furthermore, the foraminifera, occurring as they do in the pebbles and not the matrix of the conglomerate, are obviously older than the conglomerate, and they were regarded by both John M. Clarke, who collected the material, and R. M. Bagg, who described it, as being either Cambrian or Ordovician in age.

In an abstract of a paper presented orally at the 1920 meeting of the Geological Society of America, the late Professor A. O. Thomas[12] stated that he had found in screenings from the Upper Devonian Lime Creek (Hackberry) shales of Iowa an abundant rotaline foraminifer, a few specimens referable to the genera *Lagena* and *Saccamina*, and a *Globigerina*-like species. Much later (1930), in another abstract, he[13] referred the rotaline form to the genus *Endothyra*, and in a posthumous paper he[14] illustrated and described this species in detail and called it *Endothyra gallowayi*. Since in these two later papers he did not mention the forms that he had earlier referred to *Lagena* and *Saccamina*, nor those that he had compared with *Globigerina*, it is logical to conclude that

[10] See, for example, Billings, E., Notes on some of the more remarkable genera of Silurian and Devonian fossils: *Canadian Naturalist and Geologist*, new ser., vol. 2, pp. 192, 198, 1865; and Miller, S. A., North American Geology and Palaeontology, pp. 151, 155–156, 1889.

[11] Bagg, R. M., The foraminifera of the Bonaventure cherts of Gaspé: *New York State Mus. Bull.* 219, 220, pp. 149–204, 6 pls., 1920.

[12] Thomas, A. O., Small fossils from the Lime Creek shales: *Geol. Soc. America, Bull.*, vol. 32, pp. 130–131, 1921.

[13] Thomas, A. O., Foraminifera in the Iowa Devonian: *Iowa Acad. Sci., Proc.*, vol. 36, pp. 279–280, 1930.

[14] Thomas, A. O., Late Devonian foraminifera from Iowa: *Jour. Paleontology*, vol. 5, pp. 40–41, pl. 7, figs. 1–9, 1931.

he had recognized that they were not foraminifera. We have had access to the material studied by him, and in so far as we are able to ascertain, the specimens that were referred to *Lagena* are internal molds of spirally marked subspherical bodies at present generally regarded as doubtful oogonia belonging to some genus related to the modern *Chara*, and therefore tentatively referred to the Charophyta. The specimens that were assigned to *Saccamina* are bryozoans, but we have not been able to locate the specimens that were compared with *Globigerina*.

For the sake of completeness, it should be mentioned that C. L. and M. A. Fenton[15] also recognized the occurrence of "Protozoa" in the Hackberry faunas of north-central Iowa, and that Croneis, Dunn, and Hunter[16] have mentioned that they have found the Helderbergian Bailey formation of southeastern Missouri to contain foraminifera in abundance, though the assemblage does not appear to be particularly diversified. In so far as we have been able to ascertain, these are all the previous references to Devonian foraminifera contained in the literature.[17]

SYSTEMATIC DESCRIPTIONS

Genus ENDOTHYRA Phillips, 1846

ENDOTHYRA? GALLOWAYI Thomas

Rotaline foraminifer THOMAS, *1921*, Geol. Soc. America, Bull., vol. 32, pl. 131.
Endothyra sp. THOMAS, *1930*, Iowa Acad. Sci., Proc., vol. 36, pp. 279–280.
Endothyra gallowayi THOMAS, *1931*, Jour. Paleontology, vol. 5, pp. 40–41, pl. 7, figs. 1–9.

This species is fairly abundant in the *Devonocidaris jacksoni* zonule near the middle of the Cerro Gordo member of the Hackberry shale at Birds Hill, four miles southwest of Rockford, Iowa, where it occurs in association with the other two foraminifera described below. It has recently been well described and illustrated by Thomas. Our observations confirm most of his statements, but we have not been able to verify his description of the aperture and we differ from him in the interpretation of the walls; furthermore, it seems to us that the umbilici were originally filled, in part at least, by shell material.

The type specimens are not nearly as well preserved as the original figures indicate, and it is very difficult, if not impossible, to determine the original texture of the walls, for the materials of which they are composed have been entirely recrystallized during fossilization. At present, both the spiral wall and the septa seem to us to be entirely devoid of any recognizable structure, other than a certain granulation, and to consist of only one layer. We are not able to recognize layers that show any similarity or in any way correspond to the tectum and the keriotheca of *Triticites*, and we are inclined to regard the walls as being finely arena-

[15] Fenton, Carroll Lane, and Fenton, Mildred Adams, The stratigraphy and fauna of the Hackberry stage of the Upper Devonian: *Mus. Geol. Univ. Michigan Contr.*, vol. 1, p. 7, 1924.

[16] Croneis, Carey, Dunn, Paul H., and Hunter, David, Pre-Carboniferous foraminifera: *Science*, new ser., vol. 75, p. 139, 1932.

[17] See Addendum at end of paper.

ceous, although the composition of the original cement can, of course, no longer be determined. In this connection we have restudied all of the type specimens and in addition have sectioned other specimens. Furthermore, we submitted the types to Professor C. O. Dunbar, who has done much to elucidate the wall structure of the fusulinids, and to Mr. Lloyd G. Henbest, who, with Dr. Joseph A. Cushman has recently been studying the wall structure of various representatives of *Endothyra*. Both have replied that after examining the specimens at various magnifications and with various types of illumination, they believe that we are correct in assuming that the walls are arenaceous, but that they are unable to prove that this is so because of the nature of the preservation of the specimens. Also, neither was able to detect any good evidence of two distinct layers in the walls, as in *Triticites*. Mr. Henbest, however, was cautious enough to record the fact that in one or two places on the type specimens he was able to discern indications of a "quasikeriothecal structure," but that "the evidences were ambiguous and subject to other explanations."

Furthermore, Dr. Cushman, Dr. Dunbar, and Mr. Henbest have all written us that they doubt that this species should be referred to the genus *Endothyra*. We too have been of that opinion for some time, but since no specimens that we can be certain are correctly identified as *Endothyra bowmani* Phillips, the genotype of *Endothyra*, are available to us for comparisons, we are not able to settle this significant point. In this connection it should be emphasized that whereas the test of this species is almost bilaterally symmetrical, as was stated in the original description, it is distinctly not symmetrical, and this form can not be excluded from the genus *Endothyra* on the basis of shape of the test; it would have to be excluded on the basis of wall structure, and that of the specimens under consideration is not well enough preserved to merit the erection of a new genus.

Genus SEMITEXTULARIA Miller and Carmer, n. gen.

Genotype: *Semitextularia thomasi*, n. sp., described below.

Test free, small, compressed, frond-shaped, straight or nearly so, essentially symmetrical; extreme adapical portion of test is planispiral; this is followed by a biserial stage, and the later chambers are uniserial in arrangement. The planispiral portion of the test is composed of a series of subovoid chambers coiled in a single plane about a spherical proloculum; the proloculum is removed from the base by these chambers of the early coiling. In the biserial stage the earlier chambers are subovoid, but the later ones are elongate and curved, and those of the uniserial stage are inverted-depressed-U-shaped. Sutures curved, slightly depressed, indistinct in adapical portion of test but distinct in uniserial portion. Texture probably arenaceous. Test relatively smooth. Aperture multiple, consisting of two rows of small pores located in an

elongate depression in the top of the last-formed chamber.

The generic name is given to suggest the similarity of the adapical half of the test to typical *Textularia*. The specimens on which we are basing this genus show certain similarities to several of the genera of the Textulariidae, and undoubtedly they should be referred to that family. *Semitextularia* appears to be closely allied to *Spiroplectammina* and may have developed out of some member of that genus by the addition of the flattened uniserial chambers. Superficially, it resembles *Pavonia* and *Climacammina*, but it most probably represents a primitive end form in the early history of the Textulariidae.

SEMITEXTULARIA THOMASI
Miller and Carmer, n. sp.

Plate 50, figures 10*a–e*

Test free, small, being slightly less than 3/5 mm. in length, about four-fifths as wide as long, and about one-fifth as thick as long. Shape somewhat variable; typically frond-shaped and essentially symmetrical, with more or less serrate margins. However, the adapical portion of some specimens is relatively narrow and in others is more or less curved in the plane of the flattening. Cross section of test lenticular except in last-formed chamber, where it is narrowly elliptical. Longitudinal section somewhat irregular but in general compressed-V-shaped.

The adapical portion of the test is planispiral and the first four chambers, which are subovoid in shape, are coiled about a spherical proloculum, which is thus removed from the base of the test. The planispiral arrangement of these early chambers has been observed only in one of the better preserved specimens with the aid of transmitted light. This internal construction of the adapical portion of the test is very feebly manifested on the exterior. The following five chambers are biserially arranged, and the last six chambers are uniserial In well-preserved specimens there is a minute spine on the termination of each of the chambers in the uniserial portion of the test.

Sutures slightly depressed, more or less obliterated by the coarser sand grains on the exterior of the test, but distinct in the uniserial portion of most specimens and discernible with difficulty in the adapical portion of well-preserved specimens.

Texture finely arenaceous or agglutinated with two sizes of sand grains. A few relatively large sand grains adhere to the exterior of the test, but otherwise the test is fairly smooth.

Aperture multiple and consists of two groups of five small circular pores arranged alternately in a double row; one group is located in each end of an elongate depression in the top of the last-formed chamber.

Remarks.—The specific name is given in honor of the late Professor A. O. Thomas, who described the first foraminifera known from the Devonian of North America.

The planispiral arrangement of the early chambers of this form was first called to our attention by Dr. Joseph A. Cushman, and the above descrip-

tion is based in part on notes sent us by Dr. Cushman.

Occurrence.—*Devonocidaris jacksoni* zonule, near the middle of the Cerro Gordo member of the Hackberry, Birds Hill four miles southwest of Rockford, Iowa.

Cotypes.—State University of Iowa, 12,018.

Genus LITUOTUBA Rhumbler, 1895

LITUOTUBA DUBIA

Miller and Carmer, n. sp.

Plate 50, figures 11*a–c*

Test small, claviform, earlier portion consisting of about two volutions somewhat irregularly coiled; later portion uncoiled and straight or slightly curved. Total length of figured specimens about 0.6 mm.; diameter of straight portion of test about 0.1 mm. Wall rather coarsely arenaceous, with much cement. Surface rough, due to presence of relatively large agglutinated sand grains, and marked by transverse annular constrictions somewhat irregularly spaced. These constrictions may be depressed sutures, but partitions or septa can not be discerned through the transparent wall of the test; the straight portion of the test, at least, seems to be somewhat twisted and constricted rather than divided into true chambers. Most of the specimens on which this species is being based show little or no evidence of attachment, but in one of them one side of the coiled portion and even part of the straight portion is flattened as though it was attached. Nature of aperture uncertain, but presumably it was formed by the open end of the last-formed chamber.

Remarks.—The above description is based on about twenty specimens most of which are rather fragmentary and poorly preserved. In some of them the annular constrictions are more numerous and more distinct than they are in the figured specimens.

The writers were uncertain in regard to the generic affinities of this form, and it is being referred to the genus *Lituotuba* on the advice of Dr. Joseph A. Cushman, who has examined the type specimens. Also, the above description is based in part on notes sent us by Dr. Cushman and by Mr. Lloyd G. Henbest. The genus *Lituotuba* has been reported from the Silurian (Chimney Hill of Oklahoma) by Moreman[18] and locally it occurs in considerable abundance in the Pennsylvanian.

Occurrence.—*Devonocidaris jacksoni* zonule, near the middle of the Cerro Gordo member of the Hackberry, Birds Hill, four miles southwest of Rockford, Iowa.

Cotypes.—State University of Iowa 12,020.

ADDENDUM

Since this paper was written four additional references to Devonian foraminifera have come to our attention. In 1920 W. H. Norton (*Iowa Geol. Survey*, vol. 27, p. 379) recorded the occurrence in the Otis limestone

[18] Moreman, W. L., Arenaceous foraminifera from Ordovician and Silurian limestones of Oklahoma: *Jour. Paleontology*, vol. 4, no. 1, p. 59, 1930.

(Upper? Devonian) of Iowa of some minute spiral fossils which he thought might be foraminifera; through the courtesy of Professor Norton we have been permitted to examine these fossils and whereas we are uncertain in regard to their affinities we do not believe that they are foraminifera. In 1902, in a preliminary paper which in so far as we have been able to ascertain was never followed by a final report, R. J. Schubert and Ad. Liebus (*Verh. k.-k. geol. Reichsanst.*, 1902, p. 66) stated that they had recognized in the Devonian (Étage G–g_3) of Bohemia representatives of the following genera: "*Hyperammina* (*abrescens Normann*), *Saccamina* (*Carteri Brady*) *Reophax* und *Stacheia* (*cf. polytrematoides Brady*)" and that "andere Exemplare machen die Anwesenheit von *Botellina*, *Technitella*, *Thuramina* und *Storthosphaera* wahrscheinlich." In 1932 Milon (*C.-R. Séances Soc. Géol. France*, 1932, fasc. 5, pp. 68–69) announced the discovery of two or three species of foraminifera in the Devonian (zone of *Hypothyridina cuboides*) of western France; one of them resembles the genus *Rotalia* and another is very similar to *Lingulina szechenyii* Lörenthey and *L. nankingensis* Lörenthey, originally described from the "Permo-Carboniferous" of China. Finally, in an abstract published only a few months ago, W. L. Moreman (*Geol. Soc. America, Bull.*, vol. 44, p. 193) stated that he had found arenaceous foraminifera in the Haragan formation of the Arbuckle Mountains region, Oklahoma.

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NEW DATA ON THE CORRELATION OF THE LOWER OLIGOCENE OF SOUTH AND CENTRAL AMERICA WITH THAT OF SOUTHERN MEXICO

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ABSTRACT

Lists of foraminiferal species occurring in the Alazan (lower Oligocene) shales near Papantla, Vera Cruz, Mexico, are given, and, by means of common species, the hitherto disputed age of faunas from Ecuador and Venezuela, previously described by other authors, is shown to be lower Oligocene, equivalent to the Alazan. A similar fauna is also cited from Nicaragua. Conclusions are drawn as to the areal extent of the deposits containing this characteristic foraminiferal assemblage.

During the routine microscopic examination of numerous surface samples collected recently by a field party working near Papantla in the State of Vera Cruz, Mexico, the writer was impressed by the remarkable similarity of the foraminiferal fauna of these samples to that of previously described material from Venezuela and Ecuador.[1] Inasmuch as the age of the South American material is in dispute, and since a detailed study of the Mexican fauna throws considerable light on this problem, as well as on the correlation of certain Tertiary beds of the Caribbean region, the most important results of that study are presented in this paper.

Acknowledgments are due to the Pan-American Petroleum & Transport Company and the Huasteca Petroleum Company, especially to Mr. Oliver B. Knight for permission to publish the information contained herein. The writer is also indebted to Mr. Carroll H. Wegemann for permission to include certain data discovered as a result of geological work in Nicaragua.

In December, 1931, a geological field party of the Huasteca Petroleum Company collected about seventy shale samples in the vicinity of the town of Papantla, Vera Cruz, Mexico, 55 kilometers south of Tuxpam. Most of these were outcrop samples, but several were taken with a hand auger from a few feet below the surface. They consisted mostly of gray or yellow, soft, nodular, highly calcareous shale. Upon being washed they disclosed an extremely beautiful and abundant foraminiferal fauna representing the Alazan formation of

[1] Galloway, J. J., and Morrey, Margaret, A Lower Tertiary foraminiferal fauna from Manta, Ecuador; *Bull. Am. Paleontology*, vol. 15, no. 55, 1929. Cushman, J. A., A Late Tertiary fauna of Venezuela and other related regions: *Contr. Cushman Lab. Foram. Research*, vol. 5, pt. 4, p. 77, 1929.

lower Oligocene age, and possessing the perfection of preservation of the microfossils so characteristic of that formation. Few of the samples contained less than forty species of foraminifera, and in one the writer recognized more than one hundred species. The average number of species per sample was about sixty.

The exact thickness of the stratigraphic section represented by the material collected could not be determined on account of the rather complicated structural conditions in the area and the lack of suitable information from wells for comparison. Since the geological investigation did not cover the entire area of the Alazan outcrop, the lower and upper beds of the formation were not sampled. The portion missing below the lowest horizons sampled was estimated to be from 300 to 500 feet thick, while the beds lying between the highest samples and the next younger formation were thought to be of somewhat less thickness. It was obvious, however, that the material collected was distributed over several hundred feet of stratigraphic section and included a representative part of the middle and upper Alazan formation.

The Alazan at its type locality and elsewhere in the famous "Golden Lane" oil-producing region has been proved to be of lower Oligocene age by Dr. C. Wythe Cooke, from the evidence of its molluscan fauna.[2] Underlying it with either local or general unconformity is the Chapopote formation of upper Eocene age, and above it lies unconformably the Meson formation of middle and possibly upper Oligocene age. The same stratigraphic sequence occurs farther south in the vicinity of Papantla. Although the Alazan near Papantla apparently contains fewer megascopic fossils and the foraminiferal fauna is of a somewhat different general aspect from that of the equivalent beds in the oil region—a point which will be discussed later—the presence of a large number of species of foraminifera in common with the Alazan of the type locality area leaves no doubt of the lower Oligocene age of the Papantla material. A partial list of common species, including many index fossils of either the Alazan shale or the Vicksburg series of the southeastern United States, is as follows. Species that appear to be confined to the Alazan beds are marked by an asterisk (*).

PARTIAL LIST OF FORAMINIFERA FROM THE ALAZAN SHALE NEAR PAPANTLA, MEXICO

Robulus budensis (Hantken)
Lenticulina convergens (Bornemann)
Lenticulina vicksburgensis (Cushman)
Nodosaria spinicosta d'Orbigny
Frondicularia mexicana Cushman
Nonion advenus (Cushman)
Nonion hantkeni (Cushman and Applin)
Buliminella obtusata Cushman
**Bulimina alazanensis* Cushman
Bolivina caelata Cushman
Bolivina mexicana Cushman
Bolivina floridana Cushman
Bolivina tectiformis Cushman
**Bolivina tongi* Cushman
**Rectobolivina mexicana* Cushman
Bifarina vicksburgensis (Cushman)
Uvigerina byramensis Cushman

[2] Cooke, C. Wythe, New Vicksburg (Oligocene) mollusks from Mexico: *Proc. U. S. Nat. Mus.*, vol. 73, art. 10, 1928.

**Pleurostomella alazanensis* Cushman
Ellipsonodosaria verneuili (d'Orbigny)
Eponides byramensis (Cushman)
Epistomina elegans (d'Orbigny)
Siphonina advena Cushman
Siphonina tenuicarinata Cushman
Asterigerina bracteata Cushman
**Ceratobulimina alazanensis* Cushman and Harris
Pulvinulinella culter (Jones and Parker)
Cassidulina subglobosa H. B. Brady
**Ehrenbergina semmesi* Cushman
Chilostomella ovoidea Reuss
**Pullenia alazanensis* Cushman
Sphaeroidina variabilis Reuss
Globigerina bulloides d'Orbigny
Globigerina conglomerata Schwager
**Planulina mexicana* Cushman
Cibicides americanus (Cushman)
**Cibicides ungerianus* (d'Orbigny)
**Planorbulinella larvata* (Parker and Jones)

The writer has not had opportunity to examine the material from Venezuela and Ecuador described by Dr. Cushman, Dr. Galloway and Miss Morrey, nor is he familiar with the reputedly similar fauna from Trinidad. His identifications of common species in connection with the study of the Alazan fauna of Papantla were made solely by reference to the above-cited publications of these authors; but the excellence of their descriptions and figures, as well as the splendid preservation of the Alazan microfossils rendered the task comparatively simple. Of a total of 114 valid species and varieties described from South America in the papers mentioned, nearly one-half, or 56, are found in the Alazan shale of the Papantla region. This is a remarkable similarity, especially when it is realized that the described material evidently came from only a few scattered horizons in the South American formation, and that considerably less than a complete section of the Papantla Alazan was available to the present writer. It is highly probable that further collections in both regions would reveal a much greater community of species.

The following table gives the list of species common to the South American and Papantla faunas, with the relative abundance of each species in each area, whenever mentioned:

It will be seen from a study of this table that in a majority of cases the species retain their relative abundance, in general, throughout the localities mentioned. The Mexican and South American faunas are strikingly similar, also, in the preponderance of representatives of the families Lagenidae, Buliminidae, Rotaliidae and Anomalinidae, and in the lack of the large shallow-water forms such as the nummulites and orbitoids. Likewise, the differences are of minor importance, and consist principally of the somewhat less development of the Miliolidae and Verneuilinidae in the Papantla material, as well as of a few genera of the Lagenidae.

In 1929 and 1930 a detailed geological examination of a portion of Nicaragua was made for the Pan-American Petroleum and Transport Company, under the supervision of Mr. Carroll H. Wegemann. The area investigated included most of the country lying between Lake Nicaragua and the Pacific Ocean. Extensive sample collections were made, and all the material was examined by the writer, with the assistance of Mr. Louis A. Kelley. Foraminifera were

FORAMINIFERA OF ALAZAN AGE COMMON TO MEXICO AND SOUTH AMERICA

Species	Relative Abundance		
	Papantla	Venezuela	Ecuador
Haplophragmoides emaciatum (H. B. Brady)	Very rare	Present	
Vulvulina capreolus d'Orbigny	Very rare		Present
Gaudryina globulifera Reuss	Common		Abundant
Clavulina cyclostomata (Galloway and Morrey)	Common	Present	Abundant
Sigmoilina tenuis (Czjzek)	Common	Present	Abundant
Spiroloculina limbata d'Orbigny	Common	Present	
Robulus calcar (Linne)	Rare	Common	Abundant
Robulus clericii (Fornasini)	Common	Present	Rare
Marginulina subbullata Hantken	Rare	Present	
Dentalina pauperata d'Orbigny	Rare	Present	Rare
Nodosaria acuminata Hantken	Common	Present	Common
Nodosaria longiscata d'Orbigny	Common	Present	Present
Nodosaria spinosa (d'Orbigny)	Rare	Present	Rare
Nodosaria vertebralis (Batsch)	Rare	Rare	Rare
Saracenaria italica Defrance	Rare	Very rare	
Frondicularia striata d'Orbigny	Rare		Common
Fissurina carinata Reuss	Rare		Rare
Guttulina irregularis (d'Orbigny)	Rare	Present	Present
Nonion affinis (Reuss)	Common	Common	Abundant
Nonion pompilioides (Fichtel and Moll)	Common	Common	Abundant
Plectofrondicularia vaughani Cushman	Rare	Common	Abundant
Bulimina inflata Seguenza	Common	Present	Abundant
Virgulina bramlettei Galloway and Morrey	Rare	Present	Rare
Bolivina caelata Cushman	Rare	Common	
Bolivina floridana Cushman	Common	Rare	
Bolivina pisciformis Galloway and Morrey	Common	Abundant	Abundant
Bolivina tongi Cushman	Common	Present	
Uvigerina auberiana d'Orbigny	Abundant	Common	
Uvigerina beccarii Fornasini	Abundant	Abundant	Abundant
Uvigerina hispida Schwager	Common	Common	Common
Uvigerina pygmaea d'Orbigny	Common		Common
Siphogenerina multicostata Cushman and Jarvis	Rare	Present	
Siphogenerina transversa Cushman	Abundant	Common	
Trifarina bradyi Cushman	Rare	Common	
Pleurostomella alternans Schwager	Rare	Present	Rare
Ellipsonodosaria verneuili (d'Orbigny)	Common	Abundant	Abundant
Eponides umbonatus (Reuss)	Common	Rare	Abundant
Gyroidina soldanii d'Orbigny	Common	Abundant	Abundant
Gyroidina laevis d'Orbigny	Common		Common
Siphonina tenuicarinata Cushman	Rare	Present	
Pulvinulinella culter (Jones and Parker)	Rare	Common	Rare
Pulvinulinella exigua (H. B. Brady)	Rare		Common
Cassidulina crassa d'Orbigny	Rare	Present	Absent
Cassidulina subglobosa H. B. Brady	Common	Present	Abundant
Pullenia bulloides (d'Orbigny)	Common		Abundant
Pullenia quinqueloba (Reuss)	Rare		Rare
Sphaeroidina variabilis Reuss	Common	Present	Abundant
Globigerina bulloides d'Orbigny	Abundant		Common
Globigerina conglomerata Schwager	Abundant		Abundant
Globigerina pseudobulloides Plummer	Abundant		Abundant
Globorotalia canariensis (d'Orbigny)	Very rare	Present	Abundant
Anomalina mantaensis Galloway and Morrey	Abundant		Abundant
Cibicides haidingerii (d'Orbigny)	Common		Abundant
Cibicides nucleatus (Seguenza)	Rare		Abundant
Cibicides ungerianus (d'Orbigny)	Abundant		Abundant
Cibicides wuellerstorfi (Schwager)	Rare		Abundant

found to be fairly abundant in the older Tertiary formations of this region. Overlying the upper Eocene beds, which there contain characteristic large foraminifera of the genera *Asterocyclina*, *Camerina*, *Discocyclina*, *Operculina* and *Lepidocyclina*, is a series composed principally of soft gray or blue shales with thin interbedded sandstones. This series is apparently conformable upon the Eocene. It is in turn overlain with marked angular unconformity by poorly cemented sands and coquina beds containing *Clementia dariena dariena* (Conrad) and other typical Miocene mollusks. The Oligocene age of the shale series above the Eocene is therefore established with reasonable certainty by the stratigraphy; but in addition it carries at some horizons an excellent foraminiferal fauna which bears out the classification as Oligocene. The series as a whole is not as abundantly foraminiferal as the Alazan of Mexico, nor is the preservation of the microfossils as perfect; but a representative fauna gathered from several samples clearly indicates a correlation with that formation, as well as with the South American faunas above discussed. The following species were identified in the Nicaraguan Oligocene:

FORAMINIFERA FROM OLIGOCENE BEDS IN NICARAGUA

Vulvulina advena Cushman
Clavulina cyclostomata (Galloway and Morrey)
Spiroloculina limbata d'Orbigny
Triloculina (several species)
Pyrgo (one or two species)
Lenticulina cornellina Cole
Lenticulina subaculeata (Cushman) var. *glabrata* (Cushman)
Robulus protuberans (Cushman)
Robulus calcar (Linne)
Robulus deformis (Reuss)
Robulus deformis (Reuss) var.
Robulus clericii (Fornasini)
Marginulina subbullata Hantken
Nodosaria ewaldi Reuss
Pseudoglandulina gallowayi Cushman
Saracenaria italica Defrance
Frondicularia tenuissima Hantken
Glandulina laevigata d'Orbigny
Guttulina irregularis (d'Orbigny)
Nonion pompilioides (Fichtel and Moll)
Camerina sp.
Pavonina mexicana Cushman
Plectofrondicularia trinitatensis Cushman and Jarvis
Bulimina inflata Seguenza
Bulimina sculptilis Cushman
Bolivina mantaensis Cushman
Bolivina mexicana Cushman
Uvigerina auberiana d'Orbigny
Uvigerina beccarii Fornasini
Uvigerina gallowayi Cushman
Pleurostomella alternans Schwager
Ellipsonodosaria verneuili (d'Orbigny)
Gyroidina laevis d'Orbigny
Gyroidina soldanii d'Orbigny
Eponides byramensis (Cushman)
Eponides umbonatus (Reuss)
Siphonina advena Cushman
Siphonina tenuicarinata Cushman
Ceratobulimina alazanensis Cushman and Harris
Pulvinulinella culter (Jones and Parker)
Cassidulina subglobosa H. B. Brady
Ehrenbergina sp.
Pullenia bulloides (d'Orbigny)
Pullenia quinqueloba (Reuss)
Sphaeroidina variabilis Reuss
Globigerina bulloides d'Orbigny
Globigerina conglomerata Schwager
Anomalina affinis (Hantken)
Planulina mexicana Cushman
Cibicides haidingerii (d'Orbigny)
Cibicides wuellerstorfi (Schwager)

The preceding fossil lists furnish strong evidence that the faunas de-

scribed from Manta, Ecuador, and the District of Zemorra, Venezuela, are neither upper Eocene in age, as maintained by Galloway and Morrey, nor Miocene, as contended by Cushman, but are lower Oligocene, and should be correlated with the Alazan of Mexico. These authors were doubtless led to overlook this correlation chiefly by the fact that little has yet been published on the foraminifera of the Alazan as developed in the State of Vera Cruz between the Tuxpam and Nautla Rivers.

Additional evidence that the collection from Manta is not of Miocene age is afforded by Mr. George Sheppard, who states,[3] "To the writer's knowledge, no Miocene rocks have been recorded north of Colonche, nor do they occur along the coast on the north as far as Manta."

The Alazan formation is exposed over a wide area in Mexico and deserves to rank as one of the standard Oligocene units of the Western Hemisphere. In the abundance and variety of its foraminiferal assemblage, and the color and preservation of the individuals, it is probably unsurpassed by any other formation in the world.

North of the Tuxpam River, at least in the vicinity of the South Fields oil region, the Alazan fauna, considered as a whole, undergoes a rather abrupt change. Whereas in the Papantla area the fauna in the middle and upper parts of the formation is dominated by *Siphogenerina transversa*, *Anomalina mantaensis*, and various species of *Cibicides*, with *Uvigerina* and *Bolivina* occupying a relatively subordinate position except at occasional horizons, the northern phase is characterized especially by enormous numbers of *Uvigerina* represented by several species and varieties. Also very abundant are *Bolivina mexicana* and varieties and *Bulimina sculptilis* Cushman, while *Siphogenerina transversa* and *Anomalina mantaensis* are very rare, if not entirely absent. In other respects the faunas are very similar in the two areas, although *Planulina mexicana* is much more common in the South Fields region than in the shales near Papantla. This fact suggests that the Alazan north of the Tuxpam River may have been deposited in deeper water than the equivalent beds farther south, and perhaps accounts for these major differences in paleontological aspect, since the genus *Planulina* lives commonly in the fairly deep portions of the present tropical seas.

In summarizing the above data, it may be stated with reasonable assurance that deposits of lower Oligocene age bearing a rich fauna of smaller foraminifera may be traced, with some interruptions, from northwestern South America through Nicaragua to southern and eastern Mexico, and thence as far north as northern Tamaulipas. In Mexico these deposits have been established as the Alazan formation, and in Central and South America the equivalence in age is based upon the large percentage of foraminiferal species

[3] Notes on the Miocene of Ecuador: *Am. Assoc. Petroleum Geologists, Bull.*, vol. 12, no. 6, p. 673, June, 1928.

held in common with the Alazan. Such a correlation throws new light on the paleography of the lower Oligocene in the region of the Caribbean Sea and Gulf of Mecixo, and further substantiates the existence of an interoceanic connection through Central America at that time. It is probable that future work in the Isthmus of Tehuantepec, in other parts of Central America, in the Antilles region, and in Colombia will make definitely known the existence of strata containing this characteristic fauna, thus closing the gaps in this part of the geologic record.

PALEONTOLOGICAL NOTES

A METHOD OF CONCENTRATING FORAMINIFERA

CARLTON M. CARSON

The method here described was developed in Venezuela and has been applied to many hundreds of outcrop and core samples, from both the Tertiary and Cretaceous. The courtesy of Mr. G. C. Gester of the Standard Oil Company of California permits the description of this method. Of several different processes tried, this has proved to be the most satisfactory.

A careful concentration will obviate the necessity of laboriously picking out rare forams from a large mass of sand or shale particles. The method is applicable to sandy samples in which the forams are not filled or pyritized, and to shale samples, when the shale will not break down and wash away. The forams of shales are usually pyritized and pyrite-filled or partially so.

The necessary equipment which has been found satisfactory consists of a large separation funnel, about 900 cc. capacity, a stand for the same, bromoform, funnels, beakers, stirring rods, etc. and a hot plate for drying the samples.

The sample to be concentrated should be crushed, washed in water on to a 100- or 150-mesh sieve and dried, after which it may be examined under the microscope to ascertain whether forams are present. In case any oil or bitumen is present it should be removed with chloroform or ether to avoid discoloring the bromoform. If the sample is sandy, proceed as follows: Pour bromoform, diluted with *absolute alcohol* so that a quartz crystal will just sink, into the separation funnel, add the dry sample and stir well, then allow a few minutes for separation to take place. If most of the sand does not go down, keep stirring and adding *absolute alcohol* a little at a time, until the sand settles. From below draw the heavy concentrate off on to a filter paper, recovering the alcohol-bromoform solution. Wash the concentrate two or three times with alcohol, not necessarily absolute, to recover the bromoform saturating the sample. The floating portion of the sample may now be drawn off on to another filter paper and washed as mentioned before. Dry and examine under the microscope and if too much sand remains with the forams the process should be repeated using slightly more dilute bromoform.

In the case of a sample consisting of pyritized forams and shale particles, proceed as above but using full strength bromoform. The forams will sink and can be drawn off on to filter paper, washed, dried and examined.

The addition of an excess of water to the alcohol-bromoform solution will release the bromoform to be used again.

Some practice may prove necessary to obtain a clean separation of forams from sand at the first attempt but after some experience very beautiful concentrates can be prepared.

ADDITIONS TO THE PLIOCENE FAUNA OF TURTLE BAY, LOWER CALIFORNIA, WITH A NOTE ON THE MIOCENE DIATOMITE

LEO GEORGE HERTLEIN

During the return trip from the Galapagos Islands on Captain G. Allan Hancock's yacht *Velero* III, a short stop was made at Turtle Bay, Lower California. The writer took advantage of this opportunity to collect from the lower 20 to 30 meters of yellowish-gray Pliocene beds which overlie the white Miocene sediment at the north end of the bay. The Pliocene beds dip to the south about 5°.

Several of the species collected at Turtle Bay have not been reported from that locality in previous faunal lists, although certain others are already known from there and from the Cedros Island Pliocene. A review of the literature and a discussion of the fauna from these localities is given in a paper by E. K. Jordan and Hertlein.[1]

In the following list, species marked with an asterisk (*) have not been previously collected at Turtle Bay. The collection does not cause any alteration in the correlations formerly made and the conclusion that the age is middle Pliocene remains the same.

FAUNA COLLECTED FROM THE PLIOCENE BEDS OF TURTLE BAY, LOWER CALIFORNIA

Astrodapsis israelskyi E. K. Jordan and Hertlein*
Dendraster ashleyi Arnold*
Dendraster gibbsii humilis Kew*
Anomia peruviana d'Orbigny
Chama frondosa Broderip
Hinnites sp.
Ostrea erici Hertlein*
Ostrea lurida Carpenter
Ostrea megodon Hanley
Ostrea vespertina Conrad
Pecten bellilamellatus Arnold
Pecten bellus Conrad
Pecten callidus Hertlein
Pecten circularis Sowerby
Pecten cristobalensis Hertlein
Pecten gallegosi E. K. Jordan and Hertlein*
Pecten healeyi Arnold*
Pecten lecontei Arnold
Pecten praevalidus E. K. Jordan and Hertlein
Pecten stearnsii Dall*
Pecten subdolus Hertlein*
Pecten subnodosus Sowerby
Pecten veatchii Gabb*
Placunanomia hannibali E. K. Jordan and Hertlein
Spondylus crassisquama Lamarck*
Forreria wrighti E. K. Jordan and Hertlein
Balanus cf. *concavus* Bronn

DIATOMITE FROM TURTLE BAY

Among the samples collected on the north side of the bay there was one which consisted of very different matrix. Its significance was not noted at the time of collection but it is certain that it came from very close to the base of the Pliocene beds which overlie the hard white shale at that point. The sample has been examined by Dr. G. D. Hanna, who has furnished the following information:

The material is a light sulphur-yellow, loosely consolidated shale, containing some clay and very fine quartz sand. Marine diatoms are very abundant and form more than 50 per cent of the bulk of the sediment. A portion of the sample after being put through the usual preparatory processes for fossil diatoms, becomes snow-white; disintegration was complete and rapid. About five hours of search resulted in the selection of the species of diatoms listed below. Undoubtedly if more time had been spent a longer list could have been compiled, but it is believed that a sufficient number of diagnostic forms was found to definitely place the sample in the upper Miocene. Relationship with the deposit on Maria Madre Island is evident and diatomites of comparable age are widespread in California. My samples from the interior of Lower California (vicinity of Purissima) are very different.

List of diatoms found:

Actinocyclus ehrenbergii Ralfs
Actinocyclus janischii Schumann
Actinoptychus bismarckii Schmidt
Actinoptychus glabratus Grunow
Actinoptychus grundleri Schmidt
Actinoptychus undulatus (Bailey)
Actinoptychus vulgaris Schumann
Arachnoidiscus ornatus (Ehrenberg)
Aulacodiscus margaritaceous Ralfs
Auliscus coelatus Bailey
Biddulphia tuomeyi Bailey
Campyloneis grevillei (W. Smith)
Coscinodiscus diorama Schmidt
Coscinodiscus elegans Greville
Coscinodiscus evermanni Hanna and Grant

[1] Jordan, E. K., and Hertlein, L. G., Contribution to the geology and paleontology of the Tertiary of Cedros Island and adjacent parts of Lower California: *Calif. Acad. Sci., Proc.*, (4) vol. 15, no. 14, pp. 409–464, pls. 27–34, 1926.

Coscinodiscus marginatus Ehrenberg
Coscinodiscus subapiculatus Hanna, n. sp. Schmidt, Altas Diat., pl. 64, 1878, fig. 9. This name is intended for those diatoms of the *apiculatus* group in which only a part of the disk bears entirely separated beads; on the remainder the beads touch each other. Usually the free-beaded portion is a crescent shaped area at the margin; only rarely is it so extensive in west American forms as Schmidt's figure shows, so far as I have observed.
Gephyria gigantea Greville
Isthmia nervosa Kützing
Melosira clavigera Grunow
Melosira sulcata (Ehrenberg)
Podosira variegata Schmidt
Stephanopyxis appendiculata Ehrenberg
Stephanopyxis grunowii Grove and Sturt
Stephanopyxis spinosissima Grunow
Stictodiscus californicus Greville
Thalassionema nitzschoides Grunow
Xanthiopyxis globosa Ehrenberg
Xanthiopyxis umbonatus Greville

NEOSPIRIFER DUNBARI RALPH H. KING, *NOM. NOV.*

The name *Spirifer triplicata* was given by Hall[1] in 1852 to specimens collected on Missouri River above Weston, Missouri. This form came to be regarded as identical with the then poorly defined *Spirifer cameratus* of Morton,[2] and Hall's name was placed in the synonymy of Morton's species. In 1855, Shumard listed[3] among the fossils of the Missouri Coal Measures "*Spirifer triplicata* Hall (non Kutorga)," thus calling attention to the fact that the name was preoccupied.

In 1842, Kutorga[4] had described a form to which he gave the name *Spirifer triplicata*. Shumard erroneously regarded *Spirifer meusebachanus* Roemer, from San Saba Valley of Texas (1852), as identical with *Spirifer triplicatus* Hall. Hall's species remained in the synonymy of *Spirifer cameratus* Morton until 1920, when Girty showed[5] it to be a distinct and valid species and re-established it under Hall's name. Dunbar and Condra[6] in 1932 referred Hall's species to the genus *Neospirifer* of Fredericks and discussed and illustrated the form fully and carefully, but did not suggest a new name.

Tschernyschew[7] referred the form described by Kutorga to the genus *Terebratuloides*, but regardless of this fact, the name as given by Hall is a homonym, and his species demands a new name. In recognition of Dr. Dunbar's extensive work on Pennsylvanian Brachiopoda of this group in particular, as well as other forms, the name *Neospirifer dunbari* is proposed for the species originally named *Spirifer triplicata* by Hall.

[1] Hall, James, Notes upon some of the fossils collected on the route from the Missouri River to the Great Salt Lake and in the vicinity of the latter place, by the expedition under the command of Captain Howard Stansbury, T. E. Appendix E, Geology and Paleontology: Stansbury's report of the Exploration and Survey of the Valley of the Great Salt Lake of Utah, p. 410, pl. 4 (erroneously pl. 2) figs. 5*a–e*, 1852.

[2] Morton, S. G., Appendix to Hildreth's observations on the bituminous coal deposits of the Valley of the Ohio, and the accompanying rock strata, etc.: *Am. Jour. Sci.*, ser. 1, vol. 29, p. 150, pl. 2, figs. 3, 1836.

[3] Shumard, B. F., Catalogue II—Coal Measures: *Missouri Geol. Survey*, Reports I, II, App. A, p. 216, 1855.

[4] Kutorga, S., Verhandlungen der Russisch-kaiserlichen mineralogischen Gesellschaft zu *St. Petersburg, Petersb.* 8°, Jahr. 1842–1844, jährlich 1 Band. t. 23, f. 5, 6, 1842.

[5] Girty, Geo. H., Carboniferous and Triassic Faunas: *U. S. Geol. Survey, Prof. Paper* 111, Appendix, p. 645, pl. 54, fig. 22, 1920.

[6] Dunbar, C. O., and Condra, G. E., Brachiopoda of the Pennsylvanian system in Nebraska: *Nebraska Geol. Survey, Bull.* 5, ser. 2, p. 328, pl. 39, fig. 5, pl. 41, figs. 1–6, 1932.

[7] Tschernyschew, Th., Die Obercarbonischen Brachiopoden des Ural und des Timan, p. 478, pl. 21, fig. 4, 1902.

CRITERIA FOR OSTRACODE ORIENTATION

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In determining the orientation of fossil ostracode carapaces the paleontologist must weigh two types of evidence; structures of definitely known function and hypothetical interpretations of the ostracode mode of life and its structural adaptations to that mode.

Most workers agree on the interpretation of separated chambers, recurved frills, etc., as brood pouches, and are willing to concede that these structures should be located in the posterior half of the carapace. Small and indistinctly outlined swellings in the carapace, although often representing dimorphism and probably sex variation, are not *ipso facto* brood pouches. They may only indicate that the female had need for extra room somewhere within the carapace for brooding or for enlarged ovaries. This would bring about a slight displacement of the soft parts away from the posterior end, producing an inflation either in the central or the anterior part of the carapace. In the genus *Hollinella*, for example, the females tend to be proportionally thicker in the anterior region than the males, despite the fact that this genus apparently brooded its young between external frills. Therefore unless swellings are very distinct and localized it would seem that their identification as brood pouches is as yet unproven.

Because of highly developed transverse ornamentation many ostracodes could not have made much speed through the water, and it is doubtful if any ostracodes, ornamented or smooth, were speedy enough to need a perfectly streamlined carapace, blunt anteriorly. In the larger forms, however, the weight of the individual was great enough to make both sustained swimming and creeping on soft bottoms difficult tasks. Aside from thinning the carapace to reduce weight, the only way in which the carapace could be altered to overcome this difficulty would be by narrowing the anterior part, not transversely but vertically, to produce more or less of a high-prowed effect. This would help the ostracode in crossing obstacles because the anterior part of the carapace would be highest above the bottom, and it would also tend to keep the individual from sinking as it traversed very soft muds. In swimming this shape would help to keep the ostracode from sinking too rapidly as it passed through the water. On purely theoretical considerations, then, the high anterior end, with a center of gravity post-ventral of the center of the carapace, should be the shape toward which the larger ostracodes, if they were at all active, should have evolved. It would seem that the anterior shortness (recognized long ago in its complement, the "backward swing" by Ulrich and Bassler) should take precedence over median sulci, "eye spots" and posterior thickness in the orientation of fossil ostracodes.

THE PRESERVATION OF TYPE SPECIMENS

L. W. STEPHENSON
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The importance of the preservation of the type specimens of newly described species of fossil organisms is a matter which appears not to have been fully appreciated by some members of the Society of Economic Paleontologists and Mineralogists whose papers dealing with systematic paleontology have been published in this Journal.

In a letter on this subject our former president, Dr. G. Dallas Hanna, said: "A species whose type is lost might better

never have been described. A type in an institution which has no organization for caring for such material is potentially lost and much can be said against the practice of depositing types in private collections."

Those paleontologists who have had long experience in systematic paleontology will doubtless agree with Doctor Hanna. They have all been confronted with the difficult task of deciding to just what organism an author intended a given specific name to apply, when the type specimen or specimens of that organism are no longer available for inspection. This becomes doubly difficult when the original description is inadequate, and when the original illustration, if any, is poor. It sometimes happens that the task can not be successfully accomplished and the specific name ceases to have any meaning or usefulness. In such a case the originally described species is apt to be redescribed under a new name whose validity no one can successfully dispute. Present day authors are hardly excusable for failure to realize the possible futility of their efforts in the event their types become lost or destroyed.

It is essential, therefore, that an author, before proposing new names for organisms, should have made definite arrangements for depositing his type specimens in some museum of recognized standing; that the specimens should be given catalogue numbers of that museum; and that the name of the museum and the catalogue numbers should be published in connection with adequate descriptions and illustrations of the species.

The author should satisfy himself that the institution which he selects for the housing of his types is adequately provided with facilities for preserving them. This should mean that the institution is provided not only with suitable fireproof storage facilities but with curators who fully appreciate the value of type specimens, the importance of preserving them, and the tragedy of their loss.

A college or university which encourages the description of new species within its jurisdiction, and subsequently allows the indiscriminate handling of the types by immature students who do not appreciate their value or importance, is not a satisfactory depository for types. Can we wonder at the indignation of a certain paleontologist who witnessed the use of a valuable holotype for baseball practice in a classroom of one of our large State universities?

Of almost equal importance is the matter of describing the type localities of new species. Accurate data in regard to the occurrence of the type material should be regarded as an essential part of its treatment. This becomes especially apparent when a type is lost, and it becomes desirable to substitute a neotype; it is also important when questions arise as to the exact stratigraphic occurrence of type material.

A paleontologist who does not appreciate, or is indifferent to, the essential matters just mentioned should not be permitted to assume the responsibility of authorship in the Journal of Paleontology.

REVIEWS AND NEW PUBLICATIONS

MILLS, FREDERICK WM. An Index to the Genera and Species of the Diatomaceae and Their Synonyms, 1816–1932, Part I, May, 1933, pp. 1–74.

This index is the first which has appeared since 1897. The first part contains a bibliography of the most important treatises on diatoms and it is stated that the complete work contains more than 500 names of genera, probably 60,000 names of species and varieties and over half a million references. It represents an incredible amount of labor and will be of very great value to all diatomists. The arrangement is alphabetical for both genera and species and the first part takes the subject up to and including *Achnanthes vernalis*. The work is issued by the author, (address—Woodford Hall, Milton Damerel, North Devon, England), in mimeograph (multitype) form to subscribers in Great Britain and is supplied to foreign countries by Wheldon & Wesley, Ltd., (2—4 Arthur Street, New Oxford Street, London, W.C.2.) [By October 15, 1933, five parts had appeared, carrying the work to *Chaetoceros atlanticus*, 372 pages.]

G. DALLAS HANNA

A MANUAL OF FORAMINIFERA, by J. J. Galloway. Bloomington, Indiana. The Principia Press, 1933. 483 pp., 42 pls. $6.50.

This book is virtually indispensible to the working library of micropaleontologists and it may be used to advantage as a reference work by students. The chief value of the Manual, in the reviewer's opinion, lies in the author's painstaking survey of the literature on the foraminifera and the attempt to apply rigidly the rules of zoologic nomenclature. This is an important matter for the systematist. The chief defects of the book appear to be the somewhat dogmatic attitude of the author on controversial points in the classification and phylogeny of foraminifera, the dependence on literature rather than study of actual types in defining certain generic groups, and from the standpoint of the student, the rather abbreviated treatment of general features relating to the foraminifera.

Introductory material in Galloway's book includes discussion of the general character of foraminifera and a classification of protozoa (pp. 6–8), a historical review of classification of the foraminifera, with bibliography (pp. 8–13), principles of taxonomy as applied to foraminifera (pp. 14–20), a phylogenetic classification of the families of foraminifera, based on the postulate of a certain sequence in the development of wall structures (p. 21), evolution of the foraminifera, with consideration of variation, polymorphism, multiformity, recapitulation, palingenesis tachygenesis, bradygenesis, atavism, orthogenesis, isomorphism, parallelism, phyletic stages, adaptation, extinction and the subject of provincial and cosmopolitan faunas (pp. 22–29), morphology of the test (pp. 29–34), reproduction (pp. 34–35), geographic distribution (p. 35), and geologic distribution (pp. 35–36). The brevity of treatment of most of these subjects is indicated by the fact that discussion of the geographic and geologic distribution of the foraminifera, for example, occupies barely more than a single page.

The main part of the Manual is devoted to systematic descriptions of the families, subfamilies, and genera of the foraminifera (pp. 37–450). Thirty-five families are recognized. The grouping in these families is largely based on Galloway's thesis of the evolution of the wall structure in foraminifera, which is that arenaceous walls are developed from other kinds and that in no case are other kinds of walls developed from the arenaceous type. The arenaceous wall is regarded as a degenerate character rather than a primitive one and since an arenaceous test is interpreted as having been

developed directly from any other type of walls in the evolutional series—gelatinous, chitinous, granular calcareous, fibrous calcareous, alveolar calcareous, hyaline calcareous, or porcellaneous calcareous,—the occurrence of arenaceous foraminifera in Early Paleozoic strata and the appearance of various types of arenaceous tests in any part of the geologic column can be accommodated to theory. Among supporting reasons for the line of evolution advanced by Galloway are the conclusions that (1) the earliest known foraminifera are calcareous, (2) many calcareous forms have calcareous walls in the earlier ontogenetic stages and walls with contained foreign particles in the later stages, and (3) no known foraminifer has an arenaceous nepionic or neanic stage followed by a calcareous ephebic stage, as would be the case if the arenaceous wall developed into one secreted by the animal (p. 18). *Cayeuxina* Galloway, from the pre-Cambrian of Brittany, is accepted without question as belonging to the foraminifera, the thin siliceous walls being interpreted as originally fine-granular calcareous (p. 154). *Matthewina* Galloway, from the Cambrian of New Brunswick, is similarly regarded as an undoubted representative of the foraminifera with calcareous granular walls (p. 154). *Spirillina*, reported by Chapman from the Upper Cambrian of England, has hyaline calcareous walls, and Galloway notes (p. 82) that "it may be questioned that there are any Paleozoic tubular forms with agglutinated walls [such as those referred to *Ammodiscus* and *Cornuspira*], excepting a form resembling *Tolypammina*." The first appearance of arenaceous foraminifera, according to Galloway, is in the Silurian (p. 18), Moreman's records being accepted for the Silurian but not for the Ordovician.

Because the main premises on which Galloway's classification is based are not established, his grouping of genera in certain families and his characterization of certain genera will probably not be accepted immediately by other paleontologists. Nevertheless, the clear statement of his views, accompanied by carefully prepared descriptions of genera, families and subfamilies, and by detailed citations of the literature and consideration of synonymy, constitute a real addition to knowledge of the foraminifera.

The valid name of each family and subfamily is designated according to the law of priority. This leads in some cases to abandonment of commonly used names for unfamiliar names that have priority, as Nodosariidae for Lagenidae, and Ataxophragmiidae for Verneuilinidae. Under each family in the systematic descriptions reference is given to the first valid name for the family, and this is followed by definition of the family characters, notation of habitat and statement of geologic range. A phylogenetic tree for the family is given showing division into subfamilies and indicating inferred relationships of the genera. The evolution and classification of the family is discussed and keys for the subfamilies and for the genera in each subfamily are presented.

The Manual is excellently illustrated by line drawings, mostly based on figures of genotypes. These figures have the advantage of showing clearly desired features of form and structure but they suffer the disadvantage that inheres in any drawing, which at best is only an interpretation of the actual thing. The additional fact that the drawings are based on published figures very largely rather than on study of the types makes them somewhat less trustworthy, but it is an almost impossible task for an author to examine personally the widely scattered types of the described genera of foraminifera.

The latter pages of the book contain a long list of genera of foraminifera that are deemed unrecognizable, of generic *nomina nuda*, of invalid names used for foraminifera, and of genera that are not foraminifera but reported as foraminifera. There is also an extended glossary and an index. The book is well printed and is bound in dark blue cloth.

RAYMOND C. MOORE

FORAMINIFERA, THEIR CLASSIFICATION AND ECONOMIC USE (Second Edition), by Joseph A. Cushman. Sharon, Mass., Cushman Laboratory for Foraminiferal Research, Special Publication 4, 1933. 349 pp., 31 pls. (Not sold separately).

AN ILLUSTRATED KEY TO THE GENERA OF THE FORAMINIFERA, by Joseph A. Cushman. Sharon, Mass., Cushman Laboratory for Foraminiferal Research, Special Publication 5, 1933. 26 pp., 40 pls. $2.00. (Publications 4 and 5 together, $5.00).

The second edition of Cushman's invaluable book on the foraminifera is vastly improved as compared with the first one. Not only is the physical make-up, including paper, typography, press-work, and binding, decidedly better, but the addition of numerous new plates to illustrate the living animal, forms of the test, chambers, apertures, ornamentation and other features, and of new plates showing the relationships of genera in many of the families is a welcome part of the revision. Most important, however, is the division of the work into two parts, the one (Special Publication 4) consisting essentially of text and explanatory plates on structure and phylogenetic relationships of the foraminifera, and the other (Special Publication 5) containing in compact and most readily usable form keys for identification of the families and genera of the foraminifera accompanied by unusually good plates which show the characters of the genera by family groups. The plates are 6 by 9 inches in size and lack margins, so that the full size of the book page is given to illustrations. About 1,350 separate figures, including many new drawings by Doctor Cushman's very capable artist-assistant, Miss Margaret Moore, appear on these plates which have black backgrounds. The main advantage of this arrangement of keys and plates in a separate book is the possibility of studying text pages of the larger book while corresponding plates in the second book are open. This avoids the constant turning of pages (generally in the wrong direction) to find a desired plate of illustrations.

Aside from the addition of a short chapter on Research Problems concerning the Foraminifera, and the transposition of the chapter on Trimorphism from the latter part of the book to the front, there is no essential change in the organization of the second edition of the text. Closer comparison shows that very little is changed in the text of the chapters preceding the systematic descriptions. There are a few deletions and additions, but in some cases even minor editorial errors of the first edition are carried over into the second.

The systematic descriptions, comprising pages 60 to 301 of the text, define the characters of some 514 genera distributed in 47 families. Genera of little or no interest to paleontologists are excluded. The classification in families and subfamilies corresponds essentially to that of the first edition of Cushman's work. The 45 families previously recognized are distinguished here and in addition the two families, Pegidiidae and Victoriellidae. The names of authors of families and subfamilies, dates of their introduction, and citations of the literature under these heads are not given. The section on the Fusulinidae is contributed by Carl O. Dunbar, of Yale University, and that on the Orbitoididae by T. Wayland Vaughan, of the Scripps Institution. The enlarged bibliography of 37 pages, which lists the most important works on the foraminifera up to July, 1933, will be helpful to students of this group. The titles are grouped according to geographic areas and stratigraphic occurrence.

Cushman's classification which is familiar to workers on the foraminifera is partly based on interpretation of the evolution of wall structure that differs radically from the interpretation advanced by Galloway. According to Cushman's view "it may be easily and completely demonstrated that calcareous tests develop directly from arenaceous ones" (p. 13). The supposed calcareous foramini-

fera of pre-Cambrian and Early Paleozoic age that are accepted without question by Galloway are not regarded by Cushman as valid evidence that calcareous tests were developed earlier than arenaceous ones or that the calcareous types are the more primitive. *Cayeuxina* from the "pre-Cambrian (?) quartzites of France" (p. 45) is thought not to belong to the foraminifera at all, and *Matthewina* from the Cambrian of New Brunswick is placed in the same category after study of specimens in Matthew's collections. Cushman accepts the conclusion of Howell on the "*Spirillina*" from the Cambrian of England, which was based on reexamination of the specimens. This led to the view that the tests were originally chitinous and that they had been secondarily calcified. The record of Cambrian foraminifera from Russia is without value as regards the nature of the test because the fossils are internal molds. Discounting all of this testimony, therefore, Cushman calls attention to the "excellent faunas of beautifully preserved arenaceous foraminifera . . . in the Ordovician and Silurian" and the observation that "the Paleozoic foraminifera are predominantly or almost exclusively arenaceous" (p. 47) as indication that the arenaceous type of test is really the older and more primitive. The evidence of ontogeny, furthermore, is adduced in support of this view. Cushman states:

> It is apparent from a study of the arenaceous group that the ferruginous cement may, in shallow, warm waters, be largely replaced by calcareous cement. From this it is a simple step to an entirely calcareous test, a development which may be seen actually taking place in a single individual, in living and fossil species. Distinctly arenaceous walls change to calcareous ones in the same individual, but the opposite is unknown, although sometimes theoretically claimed. (p. 12).

Referring to forms such as *Endothyra*, for example, which Galloway classes as entirely calcareous, Cushman notes that:

> Sections of well-preserved material when studied with polarized light will show the presence of angular fragments of various types of minerals, and the cementing material has much chitin. This can be easily demonstrated by dissolving the calcareous material in very weak acid so as not to break up the more delicate chitinous and arenaceous elements of the test . . . . The same treatment of *Bradyina* and other Paleozoic forms yields very similar results, and proves conclusively that this entire group belongs to definitely arenaceous types. (p. 95).

Galloway (Manual, p. 160), on the other hand, says of *Bradyina:* "wall calcareous, readily and completely soluble in acid, thick, alveolar, made up of clear calcite rods set in a meshwork of darker, finely granular calcareous material."

Attention has already been called to the admirable plates of illustrations in the Key. Figures corresponding to those in the original work are somewhat larger and clearer, but in observing this the reviewer has been surprised to discover that no change in the indicated scale of magnification is made. A comparison of figures selected at random shows that the increase of magnification of the new figures ranges from about 10 to 25 percent, and yet the stated magnifications are the same in both editions. If the figures in the first edition were correctly designated as to magnification, then those of the Key are obviously incorrect. Assuming that the first edition is correct, the magnification of Plate 6, fig. 3a, for example should be given as X12.5 in the Key, and not X10. This discrepancy which affects a very large number of the figures is perhaps not an extremely vital matter, but it is at least a regrettable departure from scientific precision.

The two books by Cushman are well suited to the needs of a student in micropaleontology. They may be used satisfactorily as textbook and laboratory guide as well as for reference. Few paleontologists who are concerned in any way with work on the foraminifera will want to be without them. An introductory offer is announced stating that orders for the two volumes received before January 1, 1934, will be accepted at $4.50 if accompanied by cash. The foreign price is $6.00.

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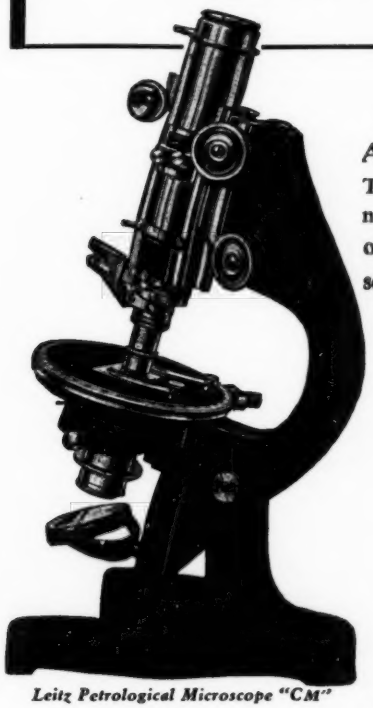

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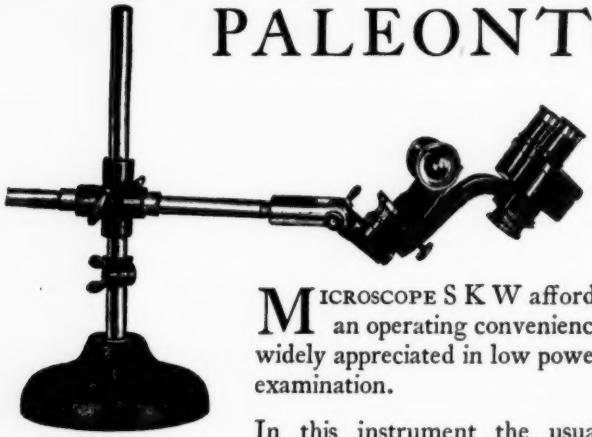

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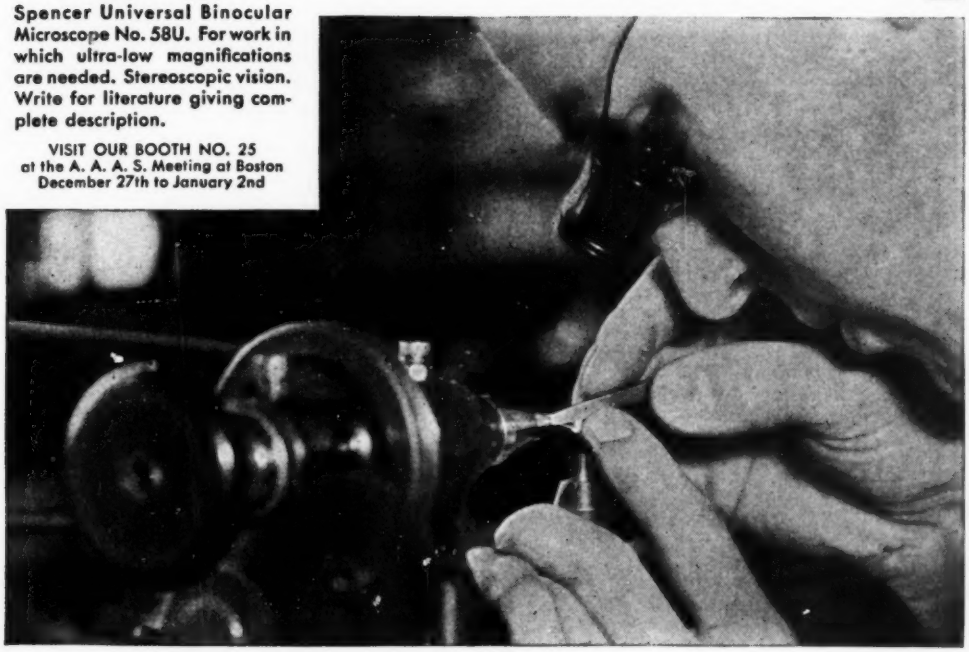

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